A TREATISE

ON

PHYSICAL GEOGRAPHY,

COMPRISING

HYDROLOGY, GEOGNOSY, GEOLOGY, METEOROLOGY, BOTANY, ZOOLOGY, AND ANTHROPOLOGY.

BY A. BARRINGTON.

EDITED BY

CHARLES BURDETT,

AUTHOR OF "THE CONVICT'S CHILD;" "NEVER TOO LATE," ETC.

"The works of the Lord are great, sought out of all them that have pleasure therein."—*Book of Psalms.*

NEW YORK:

MARK H. NEWMAN & CO., 199 BROADWAY;

CINCINNATI: W. H. MOORE & CO.; CHICAGO: S. C. GRIGGS & CO.;

AUBURN: J. C. IVISON & CO.; BOSTON: B. B. MUZZEY & CO.;

PHILADELPHIA: LIPPINCOTT, GRAMBO, & CO.; AND

FOR SALE BY ALL BOOKSELLERS.

1850.

E. G.

THOMAS B. SMITH, STEREOTYPER,
216 WILLIAM STREET, N. Y.

J. D. BEDFORD, PRINTER,
59 ANN STREET, N. Y.

PREFACE.

The subjects discussed in Physical Geography include several of the most interesting and important of those which relate to the works of nature. Thus the currents of the ocean, the motions of the atmosphere, the structure and constituents of the crust of the earth, the distribution of animals and plants, and the peculiarities and institutions of the human race, all excite a lively interest in every well-constituted mind; and a correct knowledge of them is of much practical value to those engaged in the active pursuits of life, while, in every case, it elevates the mind, and powerfully aids in freeing it from the thraldom of superstition. By studying the works of the Great Ruler, and viewing them as He views them, we participate in His pure and exalted joys, so far as our humble capacities are capable of doing so. It is not, therefore, surprising that the study of nature keeps pace with the increase of civilization, and that the more enlightened portion of the community now derive greater pleasure from tracing the workings of the beneficent Creator, than from contemplating the fancies of diseased imaginations.

The present work is designed to serve as an introduction to subjects which will repay many years' close and careful study. In so vast a field, it were vain to attempt anything more than an outline of the various subjects. We have aimed at giving such particulars as would be interesting or important to young persons and general readers; and this principle has guided us in the selection of our materials. We have omitted several things which properly belong to Physical Geography, because they are generally given in our school geographies; and we have refrained from entering on many details not foreign to our subjects, because they would be uninteresting both to those for whom we now particularly write, and to persons of greater attainments. Thus we might easily have swelled this volume to more than twice its present size, by entering at greater length into the animal and vegetable productions of the various regions of the globe, and giving a detailed account of the geological structure of such as are known. But these details would be very uninteresting to the general reader; and they would be far too meagre and unsatisfactory for the man of science. What space, *for instance, would be necessary* to give an account of the plants of

every part of the world, so full that it would serve as a book of reference for the professed botanist? We consider it much better to refer such persons to copious treatises on the various subjects on which we touch, expressly adapted for them, and to confine ourselves to such points as attract the attention of persons who do not make the subject a particular object of study. At the same time we are well aware that much interesting and important information on most of the subjects under discussion, has hitherto been found only in treatises which are generally inaccessible to those for whom this work is designed. Such information we have endeavored to supply, although, perhaps, it may be less directly connected with the mere name of Physical Geography than much which we have omitted. We considered it unwise to sacrifice the advantage and enjoyment of our readers to a mere name. The nature of the subject should rather control the name, than the name the subject. Every scientific or technical term is defined where it first occurs; and the index will direct the reader to this place: so that a glossary is unnecessary.

The following pages were originally written some years ago: but they have been carefully revised, with a view to bring every part up to the state of knowledge at the present day. We have consulted the best authorities on the various subjects, and freely availed ourselves of their labors: for we would not assume an air of originality, where we felt ourselves incompetent to improve upon the productions of others. At the same time, we have used some care in the selection of our materials, and have not hesitated to express our own views, where particular circumstances warranted us in doing so; and although we had no treatise to serve for a model, we hope the reader will find that the following work forms one harmonious whole.

In studying the great works of nature, and taking an extensive survey of the human race, we have endeavored to write in a style worthy of the subject, and to avoid the narrow and sectional views from which writers of higher pretensions are not always free. The great aim of all didactic inquiries should be—truth—whether pleasant or bitter to our personal feelings. We can only say that we have attempted to make that the great polar star of our investigations. How far we have succeeded, it is not for us to say. In a work which treats of so many subjects, and abounds so much in details, we cannot flatter ourselves that we have not occasionally been led into errors: but we hope these will be found neither numerous nor important; and we trust that the great difficulty of attaining perfect accuracy, in more than ten successive surveys of the whole world, will be an ample apology for such as may exist.

CONTENTS.

DIVISION FIRST.

HYDROLOGY, OR DESCRIPTION OF THE WATERS.

PART I.

GENERAL DESCRIPTION OF THE OCEANS AND SEAS.

PART II.

PARTICULAR DESCRIPTION OF THE WATERS AND THEIR PROPERTIES.

DIVISION SECOND.

GEOGNOSY, OR DESCRIPTION OF THE GENERAL STRUCTURE, CONFIGURATION, AND NATURAL DIVISIONS OF THE LAND.

DIVISION THIRD.

GEOLOGY, OR DESCRIPTION OF THE SOLID MASSES COMPOSING THE EARTH.

PART I.

GENERAL VIEW OF THE STRUCTURE OF THE EARTH.

PART II.

DESCRIPTION OF THE VARIOUS CLASSES OF ROCKS.

PART III.

ACCOUNT OF SOME OF THE REVOLUTIONS WHICH HAVE OCCURRED ON THE SURFACE OF THE GLOBE.

PART IV.

MINERALOGY, OR DESCRIPTION OF THE CONSTITUENTS OF ROCKS AND THEIR PRINCIPAL COMPOUNDS.

PART V.

PALAEONTOLOGY, OR DESCRIPTION OF ORGANIC REMAINS.

DIVISION FOURTH.

METEOROLOGY, OR DESCRIPTION OF THE ATMOSPHERE, AND THE PHENOMENA DEPENDENT ON HEAT, LIGHT, AND ELECTRICITY.

PART I.

DESCRIPTION OF THE ATMOSPHERE, AND ATMOSPHERIC PHENOMENA.

PART II.

ANEMOGRAPHY, OR DESCRIPTION OF THE WINDS.

PART III.

CLIMATOLOGY, OR DESCRIPTION OF CLIMATES AND THEIR LAWS.

PART IV.

VOLCANOES AND EARTHQUAKES.

DIVISION FIFTH.

BOTANY.

DIVISION SIXTH.

ZOOLOGY, OR DESCRIPTION OF THE PECULIARITIES AND DISTRIBUTION OF ANIMALS.

DIVISION SEVENTH.

ANTHROPOLOGY, OR ACCOUNT OF HUMAN RELATIONS AND INSTITUTIONS.

PART I.

ETHNOLOGY, OR ACCOUNT OF THE VARIOUS RACES AND CLASSES OF MANKIND.

PART II.

RELIGIONS.

PART III.

GOVERNMENT.

PART IV.

PUBLIC ECONOMY.

DIVISION FIRST.

HYDROLOGY, OR DESCRIPTION OF THE WATERS.

PART I.

GENERAL DESCRIPTION OF THE OCEANS AND SEAS.

§ I.—Preliminary Remarks.

The Ocean, in a general sense, consists of those immense tracts of water which surround the habitable globe, extending from pole to pole, and connected with innumerable arms, or branches, termed Seas, Bays, Gulfs, Straits, Sounds, and Channels. They all fertilize and beautify the various portions of the earth, and form one great and magnificent mass, which signally bespeaks the glorious wisdom and incomprehensible power of God. Being navigable in every part, they constitute a great highway of commerce, covered with the ships of the civilized world, and affording a medium of intercourse between the most distant portions of the earth. They are the ultimate origin of all the other waters that are found on the face of the globe.

According to some naturalists, the ocean forms the residuum of the chaotic fluid in which all solid bodies were held originally in a state of solution, and from which they have been precipitated or crystallized, and brought to their present state. It is from the vapors exhaled by the ocean that the atmosphere is furnished with sufficient moisture to support and refresh organic nature, which languishes when deprived of dews and rains. Then plants fade and droop; animals feel their strength fail; and even man himself breathes but dust, and can with difficulty procure shelter from the sultry heat by which his frame is parched and overpowered.

Geographers estimate the ocean and its branches to occupy three fourths of the entire surface of the globe; but the exact proportion between land and water has never been ascertained.

The ocean may be divided into five great basins, viz.: The Pacific, or Oriental, the Atlantic, or Western, the Indian Ocean, the Arctic, or Northern, and the Antarctic or Southern Ocean.

The total surface of these oceans is as follows:—

	Square Miles.
Pacific Ocean, ...	50,000,000
Atlantic "	25,000,000
Indian "	17,000,000
Arctic "	1,000,000
Antarctic "	30,000,000
Total Surface, ...	123,000,000

§ II.—The Pacific Ocean.

This ocean, so named from its comparative tranquillity, and often called the Oriental Ocean, separates Asia from America. It is the largest of the five great basins, and somewhat exceeds in point of extent the entire surface of the dry land. Its greatest length is from east to west, eleven thousand miles. Its breadth, eight thousand miles.

It is bounded on the east by the shores of Western and North-western America; west, by the eastern shores of Asia. On the western side, and between the tropics, its surface is studded with innumerable groups of islands, all remarkably small, and consisting in a great measure of coral reefs, rising up like a wall, and elevated but a little above the level of the sea. These islands are the work of innumerable minute insects, whose incessant labors are thus gradually forming new lands in the bosom of the ocean. The Pacific and its dependencies may be said to contain that portion of the globe termed Oceanica, or "The Maritime World," which is divided into Australasia, Malaysia, and Polynesia. Each of these divisions consists exclusively of groups of islands. On the western side, the Pacific communicates with the inland seas of Japan, and Ochotsk, the Yellow Sea, and the Chinese Sea. On the eastern side, it has the inlets of California and Queen Charlotte's Sound.

Australasia comprehends New Holland, now commonly called Australia, (by far the largest island in the world,) Papua or New Guinea, Tasmania or Van Diemen's Land, New Zealand, New Caledonia, New Hebrides, Solomon Isles, New Britain, and New Ireland, with the smaller islands adjacent. Malaysia includes Borneo, Sumatra, Java, and the rest of the Sunda Chain, Celebes, the Moluccas or Spice Islands, and the Philippines. Polynesia comprehends the *numerous groups of* islands that lie scattered through the Pacific,

from lat. 35° N. to 50° S., and from long. 100° W. to 130° E. The principal groups are the Sandwich Islands, the Marquesas or Washington Islands, the Society Islands, the Friendly or Tonga Islands, the Navigators' Islands, the Feejee Islands, Mulgrave's Archipelago, the Caroline Isles, the Ladrones, and the Loochoo Isles.

Besides the preceding, the Pacific contains many other islands, of which the most important are Hainan and Formosa, on the coast of China, the Japan Isles, the Kuriles, the Aleutian or Fox Islands, (stretching from the New World to the Old,) Vancouver's Island, the Galapagos, Juan Fernandez, and Chiloe.

On the American side, the Pacific receives no rivers of any consequence, except the Columbia and the Colorado. On the Asiatic side, it receives the waters of the Amoor, Hoang Ho, Kianku, and Mecon.

§ III.—The Atlantic Ocean.

This ocean is usually divided into North Atlantic and South Atlantic or Ethiopic Ocean. It is bounded on the east by Europe and Africa, and on the west by America. That part between Europe and North America, is frequently called the Western Ocean. The Atlantic basin extends from 70° N. lat. to 35° and 50° S. lat.; but it is only half the size of the Pacific Ocean. Its length is about 8,400 miles; its breadth, which is very unequal, varies from 1,800 to 5,400 miles. The South Atlantic contains few islands, and no inlets of any consequence. The North Atlantic abounds in large islands, and in deep and numerous inland seas, which penetrate far on each side, both into the Old and New Worlds, and fit it for the most extensive commerce on the globe. On the eastern shores it receives the Niger, Senegal, Congo, Orange, Tagus, and Loire Rivers. On the west, it receives the river La Plata, the Amazon, the Orinoco, and the Mississippi, which are the largest rivers in the world. The principal seas and bays connected with the Atlantic, on the east side, are the Mediterranean, and its dependency the Black Sea, the Bay of Biscay, the British Channel, St. George's Channel, the Irish Sea, the North Sea, and the Baltic. On the west side, it is connected with the Caribbean Sea, the Gulf of Mexico, Chesapeake Bay, Long Island Sound, the Bay of Fundy, and the Gulf of St. Lawrence. Its islands, though not so numerous as those of the Pacific, are neither few nor unimportant. On the eastern side are the British Isles, at present the most important in the whole world, (including Great Britain, Ireland, the Isle of Man, the Aebudes or Hebrides, the Orkneys, the Shetland Isles, and the Isle of Wight,) Iceland, the Faroes, the Loffoden Isles, the Azores, the Madeiras, the Canary Islands, and the Cape Verd Isles. On the western side of the

Atlantic are the Columbian Archipelago, or West Indies, (of which the most important are Cuba, Hayti, Jamaica, Porto Rico, Trinidad, and the Bahamas,) Newfoundland, and Terra del Fuego. Between the tropics the trade-winds blow steadily, but beyond these the winds are very variable; and the North Atlantic is very subject to storms, particularly between the meridians of 40° and 50° W. long. Hence navigators style this part of the Western Ocean "the roaring forties." But the Atlantic is free from those coral reefs which abound in the Pacific and Indian Oceans.

One of the most striking phenomena of this ocean is the Gulf Stream, which arises from the equinoctial currents that run together from the east, and pass through the Caribbean group of islands, towards the coast of America, into the Gulf of Mexico; thence it rushes into the Atlantic, between the Peninsula of Florida and the Island of Cuba. Here its velocity is five miles an hour. It continues to flow along the coast of the United States, expanding in width, and diminishing in rapidity, till it reaches the Banks of Newfoundland. It then turns towards the shores of Europe, where its course becomes scarcely perceptible. It may be known by the color of its waters.

§ IV.—The Indian Ocean.

The Indian Ocean, or third great basin, is bounded on the north by Asia, on the east by New Holland and the Sunda Isles, on the west by Africa, and on the south by the Antarctic Ocean. Its extreme western limit is the Cape of Good Hope, in long. 21° 27′ E., and its extreme eastern limit the southern extremity of Van Diemen's Land, in long. 147° 20′ E. Its length from north to south is about 4,000 miles; its mean breadth about 3,500. Its principal seas and gulfs are the Red Sea, the Arabian Sea, the Persian Gulf, and the Bay of Bengal. It receives the waters of the Irawaddy, Brahmapootra, Ganges, Indus, and Euphrates. Its islands are Ceylon, Madagascar, the Laccadives, the Maldives, Socotra, Andaman, Nicobar, and the Isles of France, Mauritius, and Bourbon. Numerous rocks and coral reefs render the navigation of the Indian Ocean very dangerous: but it never freezes, and it is always free from floating ice. The trade-winds prevail here, between the Tropic of Capricorn and the 10th degree of south latitude. To the north of this region the monsoons prevail.

§ V.—The Arctic Ocean

The Arctic Ocean is an immense circular basin, surrounding the North Pole, and communicating with the Pacific and the Atlantic

by two channels, one of which separates America from Europe; the other separates America from Asia. Few points of the coast of Europe and Asia, which occupy a full half of the circumscribing circle, extend much beyond the parallel of 70°; and the other boundary, consisting of the northern coasts of America, reach no nearer to the Pole. Hence, the mean diameter of the basin of the Arctic Ocean may be taken at 2,400 miles. Its interior, or central parts, are little known. Several islands are scattered over the southern extremities, the largest of which is Greenland, whose northern limits are unknown. The others, of any consideration, are Spitsbergen, Nova Zembla, the isles of New Siberia, Banks, Melville, Bathurst, Sabine, Walker, and Leopold Islands, Cornwallis Island, Cockburn's Island, and Cumberland Island.

This ocean is for a great part of the year locked up in ice; and during the rest, floating masses of the same substance endanger the life of the mariner.

The principal bays and seas connected with it are, the White Sea, the Sea of Labrador, (which separates Labrador from Greenland,) Baffin's Bay, and Hudson's Bay. From the old continent, it receives the Lena, Yenisei, Oby, and Dwina Rivers; in the new, it receives the Mackenzie, and the Coppermine Rivers.

§ VI.—Antarctic Ocean.

This ocean, which is still less known than the Arctic, joins the Pacific in the latitude of 50°, and the Indian Ocean in latitude 40° S. Floating ice occurs in every part of it, as well as in the Arctic or Northern Ocean, and literally rises to the height of small mountains. This characteristic feature of the two Polar Seas, as they are termed, has also given the name of Frozen Ocean to both Arctic and Antarctic. This ice is most abundant in the parallel of 60°. It was long supposed that a large continent of land and fixed ice occupied the greatest part of the space within the Antarctic Circle.

In 1819, South Shetland was discovered, lying between the latitude of 62°, and longitude 55 and 65°. Mr. Weddell has since examined this quarter, nearer the Pole, and he believes that it is surrounded with fixed ice. The United States Exploring Expedition have more recently discovered what is probably the long-sought southern continent. It lies south of New Holland, beyond the parallel of 60° S., and appears to be guarded by a strong barrier of everlasting ice. The enterprise of modern navigators has discovered several islands in this ocean; but they are all barren and uninhabited, and consequently of little importance. As the Antarctic Ocean is

wholly bounded by other oceans, it consequently receives no rivers, and gives off no seas or bays.

§ VII.—Detached Seas.

The sea is usually distinguished from lakes by being composed of salt water, while these consist of fresh. Hence we are somewhat astonished to learn that there are many bodies of water throughout the earth, which, though they have no apparent connection with the ocean, are composed of salt water. These we call *Detached Seas.* The most striking example of this kind is the Caspian Sea, which is 700 miles long, and 200 broad, and covers an area of 160,000 square miles. It receives the Volga, the largest river in Europe, and the Ural. But the most curious and interesting example of a detached sea is the Dead Sea in Palestine, which is 44 miles long, and 11 broad. The saline contents of the Caspian are inconsiderable; but those of the Dead Sea greatly exceed the proportion general throughout the ocean,—being 26.24 per cent.; while those of the ocean are only from 3 to 4 per cent. The Dead Sea receives the waters of the Jordan, so often mentioned in Holy Writ.

To the north and east of the Caspian Sea, occurs a range of salt lakes, one of which, the Lake of Eltonsk, contains no less than 29.13 per cent. of salts. In this range occurs the Sea of Aral, likewise brackish, and resting in the same hollow which contains the Caspian, but not connected with it. It is 250 miles long, and 120 broad, with an area of 20,000 square miles. It receives the waters of the Amoo or Oxus, and of the Sirr or Jaxartes.

In point of size, these detached seas are rivalled by the grand lakes of North America. Their saline character is a peculiarity connected with their having no outlet. The natural condition of water is the fresh state in which it falls from the clouds. It acquires its saline properties by accident. This is indicated particularly by the varying degrees of saltness even in the ocean; for it is most salt between the Tropics, where the evaporation is greatest, and least so at the Poles, owing to the infusion of melted ice. We need not, therefore, be surprised at finding that the detached seas and salt lakes are of a different degree of saltness from the mean of the ocean, or that they differ among themselves.

There is no trace of animal life in the Dead Sea. Persons who have swum on its surface, assert that its waters are light and extremely buoyant, owing to its great specific gravity. The skin smarts very much from a contact with its waters, which have a greasy feel; and they come out covered with a sensible incrustation of salt. The stories told of birds not being able to fly across without

dropping dead, in consequence of the fumes arising from it, belong to the class of fabulous and imaginary tales, produced by marvellous appearances. Sulphur, and bitumen or asphalt, are among the unusual substances contained in the waters of the Dead Sea. The Caspian Sea, also, presents, on its western shore, springs of naphtha.

For a long time, it was believed that a subterranean passage existed between the Black Sea and the Caspian, forming a secret outlet for the large quantities of water brought into the former sea by the Volga and other rivers. As evidence in favor of this supposition, it was observed that the sea calves, dolphins, and other marine mammalia of the Mediterranean and Black Seas, were of the same species with those found in the Caspian. It was thought that these animals had found their way into the Caspian through subterranean passages. Such ideas are now entirely discarded by men of science. It has long been known that the Caspian stands at a lower level than the ocean. Halley, an English astronomer of the 17th century, supposed the depression or hollow in which it rests, might have been produced by the stroke of a comet. But when, about the year 1792, some barometrical observations indicated its being fully 300 feet below the level of the ocean, that idea was pronounced absurd. The same theory, however, was afterwards adopted by close and scientific observers, and it became again the subject of serious inquiry, whether such might not actually have been the fact. After many measurements, all resulting differently, a levelling process was adopted in 1837, which proved the depression of the Caspian below the level of the sea, to be about 83 or 84 feet. But it is not only the surface of the Caspian which is concerned; for the eastern and northern shores being almost level for a large space, it appears from a calculation of Baron Humboldt, that the extent of continental land depressed below the level of the ocean, is not less than 18,000 square leagues, being more than the area of France. We are not sure that the Baron includes in this calculation the surface and precincts of the Lake of Aral, which is now believed to be about the same level with the Caspian, and divided from it by a very low tract.

Nearly about the same time, when the Russian literati were engaged in this investigation, several gentlemen of different countries, almost simultaneously, and independently of each other, discovered that there was a similar depression in the area of the Dead Sea. Lieut. Symonds, in 1841, made a trigonometrical survey of the space between Jaffa and that water, and ascertained it to be depressed below the Mediterranean, no less than 1,314 feet.* Thus the area occupied by the Dead Sea and the surrounding country, the scene

* This agrees very nearly with the recent measurement by Lieutenant Lynch, who *found it 1,317 feet.*

of some of the most remarkable events in history, appears to be a kind of pit. Even the Lake of Tiberias, seventy miles up the valley of the Jordan, was discovered by Lieut. Symonds to be 328 feet below the level of the ocean.

From the above discoveries it results, that there is no possible means of exit for the waters thrown into the Caspian and Dead Seas, besides evaporation. Great as is the volume brought in by the rivers, the sun, in these warm latitudes, is sufficiently powerful to withdraw it again, thus keeping down the surface at a certain general level lower than that of the ocean.

It is believed that the reason of the saline taste of those isolated masses of water, as well as of the ocean itself, is, as was long ago suggested by Buffon, that these waters are the ultimate residuum, or place of deposit, for the particles of salt washed by the rivers in their courses, out of the land. The Caspian is to be regarded as a co-ordinate of the great ocean itself, although on a small scale. A lake or pond into which a rivulet flowed would be another example, and even in so small a sheet of water a certain portion of salts would in time accumulate, by means of the rivulet coursing through a certain space of land. Sir Roderick Murchison, in his work on the Geology of Russia, thus describes the character of the great basin occupied by the Aral and Caspian :—"Excepting a tract of the Ust Urst, interposed between these seas, which is a plateau of miocene limestone, ranging under 1,731 feet above the level of the Caspian, this large region may be generally described as a desiccated sea bottom, entirely composed of sand, with occasional heaps of gravel, very fine, rarely argillaceous and loamy, and almost everywhere strewed over with shells, or the débris of species, some of which are now living in the adjacent Caspian Sea. This superficial formation rests on the flanks of the miocene limestone of Ust Urst, showing that it was deposited in a sea which insulated that district, which sea appears to have been one precisely resembling the present Caspian; for the fossil shells are wholly of the kinds which live in brackish seas, (*Cardium*, *Mytilus*, and *Adacnè*,) resembling these also in their being of a very limited number of species, while numerous as individuals; in which respect brackish seas differ from ordinary seas, where the species are usually of great variety." Murchison, therefore, believes that the great Steppes or Plains of Astrakan, and all the rest of that low tract, forming what may be called the Aralo-Caspian Basin, was, in comparatively modern times, but before the age of history, covered by a brackish sea, forming a sort of inner Mediterranean, fully equal to that sea in extent. This tract is, doubtless, only saved from being so now by the strength of the evaporative power. Were that power diminished to any serious extent, the large rivers now flowing into the Aral and Caspian Seas (the Oxus, the Jaxartes, the Volga, &c.)

would undoubtedly produce a sheet of water, by which this extensive portion of western Asia would be overflowed, so that the power of the sun's rays is the immediate instrument in the hands of a merciful Providence, to preserve the inhabitants of Astrakan from permanent inundation. So, in like manner, would this tract of country become the seat of the extension and prolongation of the Mediterranean Sea, if the ground intervening between it and the Black Sea, or the Sea of Azov, were to be broken down by any cause whatever, or even lowered.

It becomes an interesting subject of speculation, by what means, and in what circumstances, have the Caspian and Aral been drained or emptied down to their present diminished forms and extent. We may presume from present appearances, that the Aralo-Caspian Basin had once a greater height by at least the amount of 150 to 200 feet. The question then arises, by what height of country is this basin divided from that of the Black Sea, the only one with which a connection has been presumed to have existed? Pallas describes a certain cliff, like the border of an ancient lake, extending between the extremity of the Uralian Mountains, and a point near the upper extremity of the Sea of Azov. This is said to average about 300 feet above the Aralo-Caspian Basin. The brackish character of the ancient Caspian, decided by the nature of its shells, shows it to have been separated from the Black Sea, by an elevation sufficient to cut off all communication of their respective waters. It is generally believed by the people living in the neighborhood of the Caspian, that its waters are slowly, but constantly diminishing. We know not whether this be the fact, but we do know that a small overbalance of the evaporative power over the filling power, such as we may believe now exists, would be sufficient in the course of time to reduce the great sea of a former age to the present pair of detached lakes.

Murchison thus speculates on the subject:—"Whilst we especially invite attention to the grandeur and peculiarity of this former internal sea, we think that its diminution to the size of the present Caspian and Aral Seas, is mainly due to oscillations of its former base. The eruptive rocks which range along the Crimea, the Caucasus, and the Balkan of Khauresm or Khawezm, are fortunately at hand to explain that as igneous matter, in many forms, has sought an issue at many points in those contiguous mountains, partially raising up sedimentary deposits, and changing their mineral aspects and conditions, so, probably, have internal widely-acting expansive forces, derived from the same deep-seated source, heaved up in broad horizontal masses to the different levels at which we now find them, the bed of the great Caspian Sea, and such portions of land about it, as are admitted by all observers to lie beneath the surface of the ocean."

This *speculation is not yet* altogether satisfactory, although very

interesting; and there is an opposite theory, founded on a very important fact, which seems to call for an equal degree of attention, namely: that there are many lakes deeper than the neighboring seas, and that in their cases we should also find a sub-aerial depression, if the evaporative power were only in excess over that by which the lake is fed. The bottom of Loch Ness, for instance, is 700 or 800 feet below the surface of the North Sea. Were that lake in a sufficiently torrid climate, we should, according to this theory, see it transformed into a comparatively small salt lake, below the sea level, and occupying the bottom of a vale, precisely like that of the Jordan and Dead Sea. Lake Superior, in North America, the surface of which is 627 feet above the sea, has a bed 336 feet below that level. Here an increased evaporative power would have exactly the same effect. Such depressions of the surface, apart from the bed of the ocean, are common; the motions of the surface alluded to, although among the most unquestionable of the facts educed by Geology from the history of the past, were at their maximum of intensity at an earlier period than those of the superficial formations.

These speculations are not exclusive of the possible connection of the Black Sea with the Aralo-Caspian, in an earlier age. It has been ascertained, beyond dispute, that in some parts of the earth, the relative level of the sea and land has undergone a change to the extent of many hundreds of feet. Suppose this to have been also the case on the confines of Europe and Asia: then the Aralo-Caspian would be an inner Mediterranean, as Murchison calls it, until the waters fell below the point where they joined; after which, it would be isolated, and its drainage would commence by means of evaporation. The fish of the present Caspian are said to be a different species from those of all other parts of the earth, though they are generally called by the same names, such as salmon, sturgeon, herring, &c., but the same marine mammalia exist here, as in the Black Sea. If we could suppose the differences in the fish to be only such as differences of conditions can in the course of time effect, there would be nothing to prevent our regarding the Geology of the Caspian as an interesting memorial of the former connection of this sea with the ocean.

§ VIII.—Inland Seas.

By an inland sea, we understand one that communicates with the ocean by a strait, or narrow channel. The largest and most important of these is the Mediterranean, which has been the scene of by far the greatest number of the nautical adventures of antiquity. *It is the "Great Sea"* often mentioned in the sacred writings. It

communicates with the Atlantic by the Straits of Gibraltar. Its greatest length from east to west is about 2,350 miles, and its breadth is not short of 650 miles at the widest part. It is bounded on the north by Europe, on the south by Africa, on the east by Asia, and on the west by the Atlantic. It contains many islands; the principal of which are Corsica and Sardinia, not far from the coast of Italy; Sicily, separated from it by the Straits of Messina; Iviza, Majorca, and Minorca, on the eastern coast of Spain; the Lipari Isles, and Elba, both on the Italian coast; Malta, south of Sicily; Corfu, Cephalonia, and Zante, on the coast of Greece, (and which, together with Paxos, Anti-Paxos, Leucadia, Vathi, and Strofadia, are called the Ionian Islands,) Cerigo, an island lying at the extreme south of the Morea in Greece; Candia, or Crete, lying at the entrance of the Grecian Archipelago; the Cyclades, east of the Morea, Tasso, Lemnos, Metelin, Scio, Samos, and Rhodes,—all in the Archipelago,—and Cyprus, on the coast of Syria.

Several parts of the Mediterranean bear other names: the part on the coast of Tuscany is called the Tuscan Sea,—that between Southern Italy and Greece, the Ionian Sea,—that east of Italy, the Adriatic, or Gulf of Venice,—that north of Candia, the Grecian Sea, or Archipelago,—and the part east of Candia, the Levant.

The principal rivers that discharge into the Mediterranean are the Nile, the Maritza, the Po, the Rhone, and the Ebro.

The Black Sea, and its dependencies, the Sea of Azov, and the Sea of Marmora, contain only brackish water, and discharge a continuous current into the Mediterranean, through the Dardanelles. Hence they might not improperly be classed with lakes. The Sea of Azov receives the waters of the Don, and the Black Sea, those of the Dnieper, Bug, Dniester, Prut, and Danube. Hence it is easy to see the cause of the current which flows constantly into the Mediterranean: the surface is not sufficient to evaporate all the water which flows into it.

The Baltic resembles the Black Sea in having only brackish waters, and pouring a continuous current into its principal sea, the cause being probably the same in both cases. It receives the waters of the Neva, Duna, Niemen, Vistula, and Oder. It is frequently frozen over in winter; and has, in this condition, been repeatedly crossed by whole armies. It communicates with the North Sea by the Cattegat.

The North Sea, or German Ocean, is bounded by Great Britain and the Orkney Islands on the west, and the continent of Europe on the east; and reaches from the Straits of Dover to the Shetland Islands, where it joins the North Atlantic. It receives the waters of the Elbe, the Weser, the Rhine, the Thames, and the Tay.

PART II.

PARTICULAR DESCRIPTION OF THE WATERS, AND THEIR PROPERTIES.

§ I.—Qualities of Sea Water in general.

Sea water contains, besides pure water, several other substances in proportions which differ in different places, the principal, as commonly given, being common salt or chloride of sodium, hydrochlorate of magnesia, sulphate of magnesia, and sulphate of lime. By boiling the sea water, or confining it in pits, and exposing it to evaporation, common coarse salt is procured. The saltness of the sea is not so great near the poles as within the tropics, except where there are gulfs which receive many rivers.

Sea water contains the following per centage weight of salt in various places:

Near Iceland,	1.12
Near Norway,	1.10
In the Baltic,	1.30
North Sea, near the Thames,	1.29
In the Irish Sea,	1.40
In the Atlantic, coast of France,	1.32
Coast of Spain,	1.46
In the Mediterranean, north of Malta,	1.27

Sea water is in some places less salt at the surface than at the bottom. In the Straits of Constantinople the proportion is as 72 to 62. In the Mediterranean, as 32 to 29. Wherever it becomes more salt it loses its bitterness, and becomes, according to observations of Sparrman, like fresh water, at 60 fathoms below the surface. In order to ascertain this fact, Sparrman took a bottle of sea water from that depth. It resembled rather fresh water with common salt dissolved in it.

The saline contents of the waters of the wide ocean do not, as far as experience has gone, differ much in different latitudes, and under different meridians. The mean is about 3.5 per cent. in the weight of the water; but the saltness is more or less affected by currents and storms. It is diminished at the surface during heavy rains, and by

the discharge of rivers; but increased by evaporation, which carries off the water fresh, and leaves the salt behind. Hence, there is often little consistency in detached observations.

From a great variety of experiments, Dr. Marcet concludes, first: that the Southern Ocean contains more salt than the Northern, in the ratio of 1.0291 to 1.02757. Secondly: that the mean specific gravity of sea water, near the equator, is 1.02777, intermediate between those of the northern and southern hemispheres. Thirdly: that there is no notable difference in sea water under different meridians. Fourthly: that there is no satisfactory evidence that the sea, at great depths, is more salt than at the surface. Fifthly: that the sea, in general, contains more salt where it is deepest, and most remote from land; and that its saltness is always much diminished in the vicinity of large masses of ice. Sixthly: that small inland seas, though communicating with the ocean, are much less salt than the open ocean. Seventhly: that the Mediterranean Sea contains larger proportions of salt than the ocean. This last is explained from the fact, that a pretty strong current from the Atlantic always flows inward at the mouth of the Mediterranean, to supply, as is supposed, the water which escapes by evaporation, and leaves its salt behind. So great, however, is the influx, that this inland sea ought to have become perfect brine, or perhaps, to have deposited beds of salt, if there were no efflux; and accordingly it is maintained that there is an outward current at the bottom, which carries off this excess of salt, and prevents its deposition, in the vast hollows at the bottom. But this under current is supposed, and not proved.

The following are the mean specific gravities of the waters of different seas, according to Dr. Marcet's experiments :—

Arctic Ocean,	1.02664
Northern Hemisphere,	1.02829
Southern Hemisphere,	1.02882
Yellow Sea,	1.02291
Mediterranean Sea,	1.02930
Sea of Marmora,	1.01915
Black Sea,	1.01418
White Sea,	1.01901
Baltic,	1.01523
Lake Ourmia,	1.16507
Dead Sea,	1.11100

The saltness of inland seas is subject to many variations. At the entrance of the Black Sea, the water is salter at the bottom than at the surface. It is said that this is caused by an under current from the Mediterranean. The saltness of the inland seas is often affected by the strength and direction of the wind, either forcing in, or retard-

ing the entrance of water from the ocean. Accordingly, by the experiments of Wilcke, it appears that the saltness of the Baltic is increased by a west wind, and still more so by the north-west wind; but it undergoes a diminution when the wind is from the east. Thus, the specific gravities are, for a westerly wind, 1.0067; westerly storm, 1.0118; ditto from north-west, 1.0098; easterly wind, 1.0039. Hence, the proportion of salt in the Baltic depends, in no small degree, on the different winds; a proof that the salt is not only derived from the neighboring ocean, but that the storms have a much greater effect on this saltness than is generally supposed.

The constituent parts of sea water have been an object of much examination. The late Dr. Murray, of Edinburgh, was of opinion that there were various sources of fallacy in analyzing sea water, and that different modes of operating on the same water gave very different results. Two reasons are assigned for this, viz., that some of the different salts naturally decompose each other in the process, and that a part is lost entirely by evaporation, especially if the temperature be high. According to him, 10,000 parts of water from the Frith of Forth, (which is not sensibly different from that of the ocean,) contain 220 parts of common salt, 33 of sulphate of soda, 42 of muriate or hydrochlorate of magnesia, and 8 parts of hydrochlorate of lime. But this result differs widely from more recent analyses.

Dr. Schweitzer, in the Philosophical Magazine, for July, 1839, gives its composition as follows:—

Water,	964.745	grains.
Chloride of sodium,	27.059	"
Chloride of magnesium,	3.666	"
Sulphate of magnesia,	2.296	"
Sulphate of lime,	1.406	"
Chloride of potassium,	0.766	"
Carbonate of lime,	0.033	"
Bromide of magnesium,	0.029	"
Traces of iodine and ammoniacal salt,		
Total,	1000	

According to Dr. Bladh, the saltness of the sea, or ocean, is greater near the tropics than at the equator.

The bitterness of the ocean is very great, when taken from the surface, or near the shore; but when drawn from great depths, its taste is only saline. It would appear, therefore, that this bitterness is chiefly owing to the greater abundance of animal and vegetable matter or substances which float on the ocean, and which are decomposed or putrefying, and brought unceasingly into the ocean by the running waters or rivers.

Man never uses sea water as a beverage. Some of the lower animals, however, occasionally travel far to drink it; sheep are fond of licking the salt left by the waves on the shore, and so are horses and cattle, which appear to fatten more easily when feeding on vegetation growing on salt marshes. Sea water is also considered a cure for certain diseases.

Many attempts have been made to render sea water fit to drink, by freeing it from salt. Distillation is the most effectual method; but the expense of fuel is immense at sea, and, after all, this process does not divest it of all its bitterness. Hence, mariners often perish of thirst, amidst the mighty waters of the great deep. Sea ice, when melted, affords nearly fresh water; but, being devoid of air, its taste is not very agreeable, though it would be highly prized in times of necessity, and forms the best substitute for fresh water. A temporary relief from thirst may be obtained, it is said, from holding sea water in the mouth.

Without the quality of saltness, and without the constant agitation of its waters, which are appointed by Divine Providence, the fluid that constitutes the ocean would become corrupt, and destroy the animal life that now exists so abundantly within its bosom.

Several modern philosophers consider the ocean as the residuum of a primitive fluid, which must have once held in solution all the substances of which the globe is composed; that these sea waters, having deposited all the earthy principles, both metallic and acid, with which they were impregnated, there remains in the residuum, which constitutes the present ocean, some of the elementary principles, too intimately combined with the water to escape from it. But this theory is now generally abandoned; and it is considered that the ocean was produced by the condensation of the aqueous vapors of the primitive world.

§ II.—Color of the Ocean.

The color of the ocean varies very much in different places, but it is generally of a fine deep blue on the ocean, and green towards the coast, or in shallow water. This apparent color of the sea seems to arise from the same causes which impart a blue shade to the distant mountains, and give the atmosphere an azure hue. The rays of blue light, being most refrangible, pass in greatest quantity through the water, which, from its density and depth, makes them undergo a strong refraction. The other shades in the color of sea waters depend upon causes both local and illusory. Among the more general sources of deception, may be reckoned the aspect of the sky. Thus, an apparently dark-colored sea prognosticates a storm; and the color of

the clouds being reflected in the waves, is mistaken for the color of the sea itself. Thus red clouds give a similar blush or rosy tint to the waves; and on some occasions the edges of the waves, by refracting the solar beams like a prism, exhibit all the brilliant colors of the rainbow, which is still more nearly imitated by the refraction of the rays in the spray. Where it is shallow or transparent, the color of the bottom is frequently mistaken for that of the water; and this happens near the shore, especially near the mouths of rivers, where the diffusion of mud and other earthy matters cannot fail to affect the color of the sea. The variety of colors in the sea may probably arise, in part, from animal and vegetable substances, diffused through the waters in a putrescent state, and communicating various tints. The yellow and bright green shades seem to be owing to living marine vegetables, which grow at the bottom, stretch their fibres through the water, or spread over the surface; and it is supposed, that the color of innumerable minute animals is often confounded with that of the sea.

The Mediterranean has sometimes a purple tint. In the Gulf of Guinea the sea is white, and around the Maldive Islands it is black. The Vermeille, or Vermilion Sea, near California, has received its name from the color of its waters. The same phenomena may be seen also at the mouth of the Rio La Plata. A great number of insects may impart a peculiar tinge to an expanse of sea. The green and yellow colors found between the Canary and Cape de Verd Islands, and in the Mare Di Sargasso, arise from a marine vegetable which grows at the bottom of the ocean, and covers the surface of the water, and produces the same effect as that called efflorescence on lakes. The color of the Greenland Sea, according to Mr. Scoresby, varies from ultra-marine blue to olive green, and from the purest transparency to great opacity. These appearances, he thinks, are not transitory, but permanent; not depending upon the state of the weather, but on the quality of the water. In 1607, Hudson noticed these changes, and observed, that the sea was blue where there was ice, and green where it was open. This may have been accidental, however. The green water forms perhaps one fourth of the Greenland Sea, between latitude 74° and 80°. It often constitutes long bands, or currents, lying north and south, or north-east and south west. In 1817, Mr. Scoresby sometimes passed through stripes of pale green, olive green, and transparent blue, in the course of ten minutes. The food of the whale occurs chiefly in green water, and there the fishers look for them, and more especially in the opake green than in the transparent blue, because they do not readily see their enemies through the former. On examining the differently colored sea water, Mr. Scoresby found various substances and animalcules, *chiefly in the olive-green water*. The number of medusæ was

immense; these were one fourth of an inch asunder. Hence, a cubic foot would contain 110,592. From these and many similar observations, Mr. Scoresby concludes that the Arctic Sea owes its color to animalcules, and that these occasion the opacity of the olive-green waters. The blue is uncommonly transparent, and contains but few of the animalcules.

The ocean is generally transparent in proportion as we recede from the shore, and is decidedly more so in cold climates than in hot, owing, perhaps, to the smaller quantity of organic matter diffused in the waters of high latitudes. From this there are exceptions, as in the case of the Arctic Sea, just mentioned, and the Caribbean Sea, which is often remarkably transparent. It is not known to what depth the solar rays penetrate into the ocean; and this circumstance is probably as various as the transparency of the sea, on which it depends. Some limit the distance to 100 yards; others assign more than double that space

§ III.—Light or Phosphorescence of the Ocean.

The light or sparkling of the ocean is a magnificent and imposing spectacle. The vessel, while she ploughs her way through the deep seems to mark a furrow of fire through the billows. Each stroke seems to dash from the oar of the rower in the long-boat a brilliant, dazzling light, and at other times a tranquil, pearly one. Here, thousands of luminous points like little stars appear floating together on the surface, and multiplying to form one vast sheet of light. There the refulgent waves heave up, and rolling together, break in shining foam. At other times, appear sparkling bodies resembling fish pursuing one another.

The explanation of this phenomenon has much occupied the attention of philosophers. Valisneri, Rigaud, and Dicquenasse have shown that this light is frequently produced by a little animal called the "Glow Worm of the Sea," which has a body extremely thin and transparent, and emits a light which is dazzling and vivid, and seen at a considerable distance on the surface of the waves. The observations of Griselini, of Godeheu, of Dagelet, and Adamson, have proved that the sea contains other luminous animals, particularly polypi, and scolopendrae. The medusæ dart from their horns, or antennæ, light like that of a candle, while their bodies remain in the dark. The pennatula marina throws out so much light as to make other fish discernible at night. All the observations of M. Péron, and Langsdorff confirm this explanation. Fongéroux, Canton, Forster, and others, think that the light of the sea, when quite calm,

and appearing to emanate from its surface, is owing to the decomposition of vegetable and animal substances, which, in the process of putrefaction, emit their light or their phosphorus, as it is termed, the term being peculiar to the particular species of light. The spawn of fish also emit a light, which has occasioned the fishermen to give them the name of "Herring Lights."

It is observed that the light of the ocean is strongest before a storm, which Newton attributes to the friction of marine currents. The light which proceeds from animalcula, generally precedes a storm. Dr. Francis Buchanan has given, in the Edinburgh Philosophical Journal, a very singular and interesting account of an extraordinary shining of the sea, which occurred in 1785, in long. 61° E., and lat. 6° S., when the sea assumed the appearance of the milky-way, and was covered with luminous spots resembling the brighter stars in that constellation; and although the break and swell of the sea was so considerable as to affect the motion of the ship, neither could be seen in consequence of the dazzling light, which continued until day-break. Several buckets of water were drawn, which proved to be full of luminous bodies about a quarter of an inch long, and the same in breadth. When brought near a candle their light disappeared, but by minute attention an extremely thin white filament was observed, covering their bodies, which could be taken up with a pin's point. These animalcula moved like worms in the water, and retained their shining property when they were dry. The filament that covered them was of a uniform shining color, and like a spider's thread in thickness.

The albicores, large fish found near the coast of Africa, not far from the equator, frequently congregate and agitate the animalcules so as to excite a peculiar splendid illumination, which these emit only when agitated by the pursuit of large fish, or some other circumstance, as the concussion of the elements.

§ IV.—Temperature of the Ocean.

The temperature of the ocean has probably a tendency to follow the mean temperature of the climate; but many powerful causes interfere to modify it; thus, between the tropics, the mean temperature of the ocean at its surface is about 80°, and it generally ranges between 77° and 84°. Beyond the tropics it begins to decrease, but without observing any strict connection with the latitude; because, on account of the great specific heat of water, powerful currents cannot fail, partially, to preserve for some time, the temperature of the place whence they came. Hence, currents from the torrid zone and passing into higher latitudes raise the temperature of the ocean

above what usually belongs to such parallels. The reverse holds good of cold icy currents from the Frozen Ocean, or Arctic regions. The temperature of the ocean is much more steady than that of the superincumbent air, and has likewise a smaller annual range: unless where very shallow, it has scarcely any diurnal range.

The temperature of the ocean, on descending below the surface, generally decreases, but not according to any uniform or known law. Thus, at a depth of five fathoms, it is sometimes 1° colder; while in other instances, it requires 100 fathoms for 1°. Sometimes the cold attains its maximum at a depth of 100 fathoms, and sometimes it requires 400 or 500 fathoms. According to an experiment related by Col. Sabine, the temperature of the Caribbean Sea was 45° 50′ at a depth of 1000 fathoms, while its surface was 83°. But the enormous pressure at the bottom probably compressed the ball of the thermometer, and kept the apparent temperature above the real. In the Arctic Sea, the temperature increases with the depth. Mr. Scoresby, who first ascertained this fact, found an increase of 6.6° and 8° at the respective depths of 120 and 730 fathoms; Capt. Parry, 6° at 240 fathoms; Col. Sabine, 7.50° at 680 fathoms; Lieut. Beechy, 10° at 700 fathoms, and Mr. Fisher, 9.50° at 188 fathoms. Thus the rate of increase of temperature in the Arctic Sea has as inconstant a connection with the depth, as the decrease in the temperate and torrid zones. Sea water freezes at about 28°, after which the ice has been observed to cool down to −55°; but we cannot thence infer that a lower temperature does not occur in the Polar regions.

§ V.—Depth of the Ocean.

The depth of the ocean is a question on which our information is very imperfect, and there is little likelihood that much accurate information will ever be obtained on the subject, as far as regards the wide ocean.

According to the speculations of La Place, the depth of the ocean is comparatively small, and nearly uniform. If, therefore, it be remembered, that the bottom of the ocean is still a part of the earth's surface, and by much the greatest portion also, one would be apt to ask, why the larger part of the surface should be more level than what appears as dry land. The soundings which have been made in the ocean, are quite inadequate to decide the question. They, however, often indicate great inequalities in the depth; but how far hollows may have been filled with débris, or asperities worn down, it is not easy to say, though it is more likely that the *summits of the mountains* exposed to the alternate or combined

actions of air and moisture, suffer a more rapid abrasion than those which are wholly under water. In general, the slope of the adjacent shore is continued a great way under the water; that is, the sea is usually shallow where the shore is flat; while its depth increases rapidly by the side of a cliff or steep mountain. It is therefore probable, that some islands, though very small, may be the tops of submarine mountains as large perhaps as the highest that are seen on the surface of the earth. In many instances no bottom has been found. This might proceed either from the shortness of the line or cable used for sounding, or from its being borne aside by rapid currents. Lord Mulgrave, with a line of 4,680 feet, found no bottom in the North Atlantic. At the Straits of Dover, the central depth is 29 fathoms. The North Sea contains various shallows or Sand Banks; yet, generally speaking, the depth increases in going north; and near Bergen in Norway, it amounts to 1,140 feet. A great part of this sea, however, is less than 100 feet in depth. Most parts of the ocean have never yet been fathomed, although sounding lines five miles long have been employed. The utmost depth is supposed to be about 30,000 feet; and Sir James Ross actually found no bottom 900 miles west of St. Helena with a line of 27,600 feet.

§ VI.—Inequalities of Submarine Land.

The bottom of the sea, like the surface of the earth, varies in form. In some seas there occur flats and plains, ranging to a considerable extent; and when near the surface of the water, they form what are called Shoals. In other cases, plains of great extent occur, deep below the surface of the sea, which are denominated deep Submarine Plains. These plains, like those on dry land, sometimes contain hollows of considerable extent, and great depth. The deep hollows under the sea, off the east coast of Scotland, known as Montrose Pits, are of this description. The bottom of the sea is sometimes hilly. These hills vary in form and magnitude, and are either deeply seated, or rise above the surface of the water, forming rocks and islands. In tropical seas, the bottom, when not very deep, becomes incrusted with coral, which sometimes rises to the surface, and then forms coral reefs, coral shoals, or coral islands.

If the bottom is very deep, but sends up from below hills whose summits are not far below the level of the ocean, these, in tropical seas, also become covered with coral.

If the ocean were dried up, the surface would present mountains, valleys, and plains, which, though unseen, unquestionably exist, and are distinguished from the visible by the epithet, submarine. The bot-

tom of the sea is, moreover, inhabited, to the depth of about 1,800 feet, by immense numbers of testaceous animals. In a great many places, the madrepores form a kind of petrified forest, fixed at the bottom of the sea; and frequently this bottom presents different layers of rocks and earth, so that the granite rises up in sharp-pointed masses. Near Marseilles, marble is dug from a submarine quarry.

There are bituminous springs, and springs of fresh water, that spout up from beneath the surface of the ocean; and in the Gulf of Spezia a great spout, or fountain of fresh water, is seen to rise like a liquid hill. Similar springs furnish the inhabitants of Aradus with their daily beverage. On the southern coast of Cuba, in the Bay of Xagua, at two or three miles from land, springs of fresh water gush up with such force, in the midst of the brine, that it is dangerous for small boats to approach them; and the deeper the water is drawn from them, the fresher it is. It has been observed, that in the neighborhood of steep coasts, the bottom of the sea sinks down suddenly to a great depth, while near a low coast, and one of gentle declivity, the sea deepens very gradually.

§ VII.—Level of the Seas.

The level of the seas is generally the same everywhere. This arises from the equal pressure in every direction, which the particles of a fluid exercise upon each other. The ocean, considered as a whole, has, then, a spheroidical surface, which may be considered as the true figure of the globe. The only exception to this position, may, perhaps, be found in gulfs and inland seas, which have only a slight communication with the ocean. In these parts of the sea, the level of the water may be sometimes a little more elevated than in the ocean. It is said that the Dutch found the level of the Zuyder Zee considerably higher than that of the North Sea. The Red Sea, called the Arabian Gulf, also appears to be more elevated than the Mediterranean Sea; and in general, small portions of the sea, open only to the east, have a higher level, on account of the accumulation of waters, driven into these gulfs, as into an alley, without an outlet, by the general movement of the sea from east to west. The trade-winds, also, when they blow against the mouth of an inland sea, have a tendency to raise its level above that of the ocean. On this account it is, that the Arabian Gulf, or Red Sea, at Suez, is from 25 to 30 feet higher than the Mediterranean at Alexandria, which, from the opposite action of the wind, and the great evaporation, is supposed to be a little below the general level of the ocean.

Some gulfs and inland seas, as the Baltic and Black Seas, rise in

spring, from the copious influx of river water, and are lowered in summer by evaporation, and the efflux at their outlets. Of late years there has been considerable discussion regarding the subsidence of the Baltic, below the level it had formerly maintained. While some support this opinion, and venture to explain the cause, others deny the fact.

Both the trade-winds and the general westward motion of the ocean, force the water into the Gulf of Mexico and the Caribbean Sea, so as to maintain a higher level there than on the western coast, opposite; the difference being about 3½ feet. The consequence of this accumulation of water is, that it generates a current, moving north, which, after various windings through the Atlantic, at length reaches the western shores of Europe. This is the well-known Gulf Stream, already described.

Some naturalists allege that the débris, or alluvial matters daily abraded by the action of the weather on the surface of the land, and swept into the ocean by the streams, must, at length, raise the level of the ocean, till it cover the whole globe, unless there be some compensating process, which either makes up for the exhausted materials, or gradually elevates the entire continents above the water; it is not very easy to calculate what the alternative is. A compensating power may be situated deep in the crust of the earth. Such a compensating power exists also in volcanic elevations, the action of the coral insect, and the deposition of matter in shallow seas, till they are converted into land. It is well known, for example, that the delta of the Mississippi is now several leagues longer than when New Orleans was built.

§ VIII.—Marine Ice.

Ice is formed on the ocean, though the salt which forms one of the chief constituent parts of its water, enables it to resist the process of congelation, at the ordinary freezing point of fresh water. This quality, however, does not resist the rigor of the Arctic regions, where the temperature of the air has been seen as low as 80° below zero. Sea water freezes at 28°; but this temperature varies a little with the degree of saltness found at the particular point. Sea water parts with its salt in freezing. Hence, compact, pure sea ice affords fresh water on being melted. But when the ice is of a loose or cellular texture, (that is, full of air-holes,) its pores often contain liquid brine; and therefore, on being melted, it affords only brackish water. It is the affinity between the water and the salt which retards the congelation of sea water; because, the greater the saltness, the lower is the freezing temperature.

Detached masses of ice are occasionally met with, floating in the

ocean, at so low a parallel of latitude as 40°, in both hemispheres, having been conveyed thither by currents from the polar regions. At the parallel of 50°, they are more abundant; and there it is common, in winter, to see the shallow edges of the sea covered with ice. At 60° N. lat., the gulfs and inland seas are often frozen over their whole surface. As we proceed towards the Poles, the ice becomes more and more abundant, and of larger dimensions, till at length we come to fields of ice, and icebergs, or mountains of ice. The process of congelation begins at the surface of the sea, with the formation of slender, prismatic crystals, resembling wet snow, termed by sailors sludge. The surface is at first rough; but by the union of the numerous crystals, it becomes smooth, and forms a continued sheet, which is next broken by the agitation of the water into fragments of about three inches diameter; these again coalesce into a stronger sheet, which in its turn is broken as before, but into larger fragments, called *pancake* ice.

Where the water is free from agitation, and the surface perfectly calm, the congelation goes on more regularly, and more rapidly. During twenty-four hours of keen frost, the ice frequently attains a thickness of from two to three inches, and is soon fit to walk on, when it is called *bay* ice. When the thickness is about a foot, it is called *light* ice; and when three feet thick, *heavy* ice. The term *field*, is given to a sheet of ice so extensive that its farthest end cannot be seen from the mast-head. Very large, loosened pieces, whose boundaries may be seen readily, are called *floes*. Fragments of thick ice floating together, are called *brash* ice. Floating ice of any sort, sufficiently loose to permit a vessel to pass through, is called *open*, or *drift* ice.

The sudden disruption of extensive fields is sometimes produced by that powerful tendency to undulation of the surface called ground swell, which is communicated by the motions of the adjoining liquid surface of the ocean during a continued storm. The ice, when thin, merely yields; but if thick, it is broken with a tremendous noise. A very interesting account of such a phenomenon is given by a party of missionaries, who passed along the coast of Labrador, in sledges, drawn by dogs. They narrowly escaped destruction, but were near enough to witness it in all its grandeur. The immense fields of ice, rising out of the ocean, clashing against one another, and then plunging into the deep, with a violence which no language can describe, and with a noise like the discharge of a thousand cannon, that struck even the minds of the poor Esquimaux with such solemn awe, that they unanimously expressed their gratitude to God for their escape, and acknowledged his glorious omnipotence.*

* *See Brown's History of the* Propagation of Christianity.—Vol. II. p. 57.

Though water undergoes a great expansion in the act of freezing, yet ice obeys the ordinary law of solids: that of expanding by heat, and contracting by cold. The effect, therefore, of intense cold, is to contract ice, which, if of large dimensions, or fixed all around, has no alternative but to break where it is contracting most. This is often attended with a tremendous report. On the contrary, a rise of temperature may not only bring the parts to meet again, but often makes them lap over, or burst up with great violence.

§ IX.—Icebergs, and their Effects on Navigation.

The term *iceberg* is applied to huge masses of ice, resembling mountains, whether floating on the sea, or resting on land. The smaller icebergs appear to be sometimes formed in the sea itself, by the accumulation of ice and snow; but the larger seem to be fragments of land icebergs, or glaciers, which have been piled up on shore till quite overgrown, and ultimately broken and launched into the ocean by their own weight. Masses of this sort abound in Baffin's Bay, where they are sometimes two miles long, and one half or one third as broad. They are bristled with various spires, rising sometimes 100 feet above the water, and descending much more below it. When compact ice floats in water, the part under the surface is nine times as thick as that above it; and hence, the icebergs may sometimes descend to a great depth, though they should be far from consisting of very compact ice.

Icebergs of an even surface, rising 90 feet above the sea, and having an area of five or six miles square, are very common. Those of East Greenland are of an inferior size; and they are still smaller around Spitzbergen, where some of enormous dimensions appear on shore. The reason assigned for this is, that owing to the shallowness of the water into which the huge fragments are precipitated, they are all shattered against the bottom into a thousand pieces, before they are fairly launched into deep water. When a glacier begins to give way, it leans majestically forward, and precipitates itself into the ocean, either in large fragments, or in one huge mass, producing a noise like thunder, and raising clouds of smoke like those of a furious cannonade.

Icebergs variously affect navigation. They are often highly useful by protecting navigators from gales of wind, as well as from the concussions of drift ice, which moves more quickly than icebergs when acted upon by the wind. Ships are sometimes moored or anchored to icebergs, but not without danger, for these floating masses are so nicely balanced as to be easily overturned should they happen to strike against the bottom of the sea. The concussion

produced in this way sometimes detaches large fragments; and sometimes the iceberg rolls forward, to the imminent danger of the vessel, though 100 yards distant; so great are the waves and whirls caused by such an occurrence.

It does not appear that any navigator has been within 6° of the North Pole, although some accounts pretend to a nearer approach. Captain Parry, in his last voyage, reached to 82° 45′, and this is the nearest approach certainly known. The failure of Captain Cook's attempt to penetrate to the South Pole, gave rise to an idea which has been pretty generally entertained since his time, that the South Pole is surrounded with fixed ice to the distance of 18° or 19°; and a more recent Russian expedition gave still worse hopes, as they could not get beyond the latitude of 70° south. Mr. Weddell has since that period reached 255 miles nearer to the Pole, and met with no obstruction. This enterprising navigator contends strenuously that the South Pole must be free from ice, and might be reached in a suitable vessel. But the late exploring expeditions have not penetrated further than 79°; and the obstacles which they encountered were such as will probably deter future navigators from venturing further. The cold is so intense and steady in the most southerly lands which they discovered, that they exhibit not a trace of vegetation.

§ X.—Motions of the Ocean.

The waters of the ocean are perpetually in motion; and it is believed that, without this provision of Divine Wisdom for the economy of nature, in place of tempering and purifying the air, they would themselves become putrid, and destroy all animal life, both within their surface and on land.

The water of the ocean yields to the slightest impression; and although its density and weight combine to retain it in a constant equilibrium, it is agitated to a certain depth by very rapid and varied motions. These motions may be classed according to the manner in which the particles that compose the fluid move, or the nature of the agents which give rise to the motion. Difference of direction distinguishes the horizontal motion from the vertical. In the first, the water flows along the surface of the globe; in others, it only retires from the surface and approaches the centre. Horizontal motions may be direct, or recurved, or circular. On the extent and duration of motion, depends the difference between oscillations, in which the whole mass of waters is moved at once, and undulations, in which the motion is propagated from one part of the mass to the other. With reference to their cause, the

motions of the ocean may be divided into three kinds, sidereal, atmospheric, and internal. The sidereal are those which depend upon the influence of the heavenly bodies, constituting the tides; the atmospheric are those produced by the action of the winds, forming waves and some currents; the internal motions are those caused by the action of terrestrial gravitation, and include all the motions not due to the other two causes. With regard to those violent oscillations which accompany earthquakes, and arise from hidden volcanoes, they may be called sea-quakes; they are only of occasional occurrence, and so local that they cannot with propriety be classed with the ordinary and constant motions of the ocean.

In respect to the present subject, the ocean may be divided into three beds, or strata, of varying thickness: 1st, that agitated by the winds—the region of waves; 2d, the region of currents, extending deeper than the preceding; and 3d, the immovable region, where the gravity and cohesion of the particles counteract the action of waves and currents, and prevent all motion, except such as may arise from occasional agencies. This region is of course below the others, and includes all the waters between the lower limits of the 2d and the bottom of the ocean.

§ XI.—Waves.

The motions which first present themselves to our notice, are those partial and alternate risings and fallings of the surface known by the name of waves, or undulations. The friction of the wind on the uneven surface of the water causes a slight swell, and as the hollow is protected, the next blast increases the swell, till it becomes one of those huge masses of moving water, the sight of which fills every mind susceptible of high emotions, with joyous awe and admiration. Waves are scarcely ever without progressive motion; but the real progress of the surface of the water is generally small, compared to the apparent motion of the waves, as is easily proved from every floating body which does not rise above the surface, so as to be hurried forward by the wind.

Waves are distinguished into natural and accidental. The natural are proportional to the strength of the wind producing them. Unequal and violent winds give rise to waves which tower aloft, like foaming mountains, roll, rebound, and dash against each other. A strong, constant, and equal wind produces long, ridgy waves, which all rise with the same front, push forward with the same velocity, and finally precipitate themselves, in regular succession, on the shore, or other opposing object. Sometimes a wave suspended by a gust of

wind, or arrested by a current, forms a liquid wall, to the imminent danger of the navigator.

In rounding the Cape of Good Hope, waves, or rather swells, are met with so vast, that a few ridges and a few depressions occupy the extent of a mile; but these are not so troublesome to navigators as a short swell, with more perpendicular waves. The slopes in the former are so gentle, that the rising and falling is rarely felt, while the latter, by the sudden plunging of the vessel, is often destructive. The large waves just mentioned, proceed at the rate of from 30 to 40 miles an hour. It is a common error to suppose that the water itself advances with the speed of the wave, while in fact, the former only advances; the substance, with the exception of a little spray, remains, rising and falling, in the same place, with the regularity of a pendulum. When a wave, however, reaches a shallow bank, or beach, the water becomes really progressive; because, then as it cannot sink directly down, it falls over and forward. Although the expression, "billows mountain high," has become proverbial, the tops of the very highest waves are never more than 40 feet above the next depression. But a wave coming against any obstacle can be raised up to a much greater elevation; more particularly if the opposing obstacle has a contrary motion, as frequently happens at the mouths of some great rivers. The enormous waves produced in such circumstances, (termed *bores*,) sometimes roll on with great velocity, to the extreme danger of navigators and their ships. They are generally highest at spring tides. The most sublime and remarkable example of this phenomenon, is that which is seen at the mouth of the Orellana, or Amazons, where the wave is sometimes 180 feet high.

Accidental waves are occasioned by the repercussion of the winds from the hills and bold coasts, and by the dashing of the waves on rocks and shoals. Waves are always seen to roll towards the shore; but any obstacle opposed to their progress, becomes the centre of a new series, which spread in circles. One set of waves, however, may not interfere with the motion of another, and they may mutually cross without interruption.

Breakers, or waves which break against some obstacle, when formed over a great extent of shore, are distinguished by the name of *surf*. The surf is greatest in those parts of the ocean where the wind blows always nearly in the same direction. The depth to which ordinary waves agitate the waters has not been ascertained with any degree of accuracy. Divers, however, assert that at the depth of 90 feet calm water is found, even when the surface is agitated by a violent tempest; and it is supposed the influence of waves does not go down beyond 40 feet. Geometricians have attempted to subject the motions of the waves to calculation; and they assert, that the propagation of waves would be equal to the descent of a heavy body, from a

height equal to one half the depth of water in the channel. Conse quently, the depth being one foot, the velocity of the waves would be 5.005 feet in one second of time, and if the depth be greater or less, the velocity of the waves will vary in the sub-duplicate ratio of the depths, provided they are not too considerable. But these calculations are deemed, by good judges, very unsatisfactory.

We must distinguish the waves produced by the momentary action of the wind, and those which arise from the impulse communi cated by the preceding wind, or by a current, or by any other cause. Navigators often experience this double oscillation, which contributes to augment the agitation of the vessel.

§ XII.—General Nature of Tides.

The tides of the ocean are those regular and periodical oscillations which the waters of the ocean undergo, from the respective attractions of the sun and moon.

The motion of a planet revolving round the sun, depends on the comparative strength of the centrifugal and centripetal forces. Whatever gives a proportionate increase to the latter, will make the planet's path curve in more rapidly than it otherwise would; and whatever gives a preponderance to the former, will render the path less curved, and *vice versa*. These facts, combined with the law of gravitation, explain the phenomena of the tides. Suppose, first, that the earth revolves round the sun, unaccompanied with any moon, and not revolving on its axis, its figure would assume a spheroidal form, owing to the slight cohesion of the particles of water, and the nearer side being attracted more, while the farther side was attracted less strongly than the centre. Two elevations of water, therefore, (i. e. two tides,) would appear, the one highest at the point nearest the sun, and the other at the opposite point. As the surrounding waters would move towards these two points, the remoter waters, being left without support, would, under the influence of terrestrial gravity, flow towards the same points. Hence they would be depressed, and this depression would be greatest at the circle of quadrature, or that of which the above-mentioned points are the poles.

If now the earth began to revolve on its axis, the waters would still rise towards the same points, and flow away from the circle of quadrature, since the action of the centrifugal and centripetal forces remained unchanged. But owing to the *vis inertiæ*, (or resisting force,) and cohesion of the particles of water, the highest swell would fall considerably behind the line of the syzygies, (i. e. a line passing through the centres of the sun and the earth,) for it would take some time before the new motion would be communicated to the water.

The result, therefore, would be a periodical rise and fall of the waters of the ocean, all round the earth, once in twenty-four hours, high water occurring some time after noon and midnight, and low water in the intervals.

If now we introduce the moon, it is evident that its action will greatly modify that of the sun. But as the attraction of the moon on the earth is much feebler than that of the sun, (its proximity by no means counterbalancing its minute size,) we do not at first perceive why the moon should have so much more influence on the tides than the sun. This is owing to the fact, that the difference of the attraction which it exerts on the nearer and further sides of the earth, is greater than in the case of the sun; for the earth's diameter is about one thirtieth of the moon's distance, while it is little more than one twelve-thousandth of the sun's. Now it is upon this difference, and not upon the absolute attraction, that the size of the tide will depend; for it is evident that if every part of the earth were equally attracted, no matter how strongly, there would be no tide. When the moon is one quarter old, it is on the earth's track, behind. Here it of course retards the onward motion of the water next to it, more than it does that of the earth's centre, while it acts still less feebly on the most remote part of the earth. Hence, as in the case of the sun, it will raise a tide at the nearest and furthest points, and depress the waters on the intermediate circle. It is also manifest that in this position, the solar or sun's tide counteracts the lunar or moon's tide; but, for the reason just mentioned, the latter is the larger; and, therefore, there is a small tide under, and another opposite to the moon. When the moon is three quarters old, she is on the earth's track, before. Here the result is the same as in the former position, although the moon's action hastens, instead of diminishing the earth's velocity. At new and full moon, the attractions of the sun and moon co-operate, instead of counteracting each other. Hence, the highest tides, termed *spring* tides, occur at these periods. The lowest tides, which happen when the moon is in quadrature, are termed *neap* tides. The influence of the causes already mentioned, however, retards the time of spring and neap tides; and therefore they happen a little after the commencement of the respective quarters of the moon. The principal modifications of the tides arising from other causes, will be shown in the following section.

§ XIII.—Peculiarities of Tides.

The proximity of the sun and moon in the heavens, causes the extraordinary spring tides which happen before the vernal and after the autumnal equinox. But they do not happen every year, because

variations are sometimes produced by the particular situation of the moon. The least spring tides occur shortly after the solstices, as the sun and moon are then farthest asunder. The tides are affected by the great inequality in the depth of the sea, the situation of the coasts, their declivity under the water, (sometimes rapid and sometimes otherwise,) the different breadths of the channels and straits, and also by winds and currents. All these local, and sometimes accidental circumstances, alter the progress of the tides, and make them deviate from the regularity which they would otherwise maintain in the open sea. Thus we see, in the islands of the South Sea, regular tides of only one or two feet elevation; while upon the western coasts of Europe, and upon the eastern coasts of Asia, the tides are extremely strong, and subject to many variations.

Upon the coasts of France, which border on the British Channel, the tide, being confined in a basin, and at the same time repelled by the coasts of England, rises to an enormous height, which sometimes renders the navigation very perilous. At St. Malo it rises to 50 feet. Sometimes several tide-waves unite. Thus, at the mouth of the Elbe, the tide is sometimes the result of three forces: one flux comes from the Straits of Calais, another from the Orkney Islands, and a third from the waters of the Elbe. The mean height of the tide at Hamburg is 6 feet 8 inches; the spring tide is generally 7 feet 3 inches; but when the wind blows with violence from the north-west, the tide rises to the height of 18, and sometimes to upwards of 20 feet. Hamburg is 30 leagues from the mouth of the Elbe, and the tide traverses this space in 5 hours and 23 minutes, but when it arrives at the mouth of the river, it takes from three quarters of an hour to one hour and a quarter, to force back or overcome the river current. The same current makes the flood-tide, at Hamburg, last only 4 hours and 18 minutes; and the reflux, or ebb-tide, 8 hours and 6 minutes.

In the torrid zone, the flood-tides run from east to west; in the north temperate zone, they come from the south; and in the south temperate zone, from the north. Both the temperate zones are affected by the greater influence which the sun and moon have upon the waters of the torrid zone, which are more directly under their agency. To this general fact, there are exceptions of a local nature. The frozen zone of the north has very few tides; its distance from the equator, and the land which surrounds it, as well as the ice with which its seas are encumbered, all combine to destroy the effect of sidereal attraction. Little is known of the tides in the south frozen zone.

The instant of low water is nearly, but not exactly, in the middle of the interval between two high waters. The tide generally takes *nine or ten minutes* longer in ebbing than in flowing. The interval

between two high waters is least during spring tides, when it is 12 hours, 19 minutes. At neap tides the interval is greatest, viz., 12 hours, 30 miuutes. The time of high water is mostly regulated by the moon, and in the open sea, it is from two to three hours after that planet passes the meridian, either above, or under the horizon. On the shores of large continents, and where there are shallows and obstructions, great irregularities take place in this respect, and when these exceed six hours, high water apparently precedes the passage of the moon over the meridian.

The highest of the spring tides is not that immediately after the new or full moon, but it is, in general, the third, and in some cases the fourth. The lowest of the neap tides occur much about the same time after the quarters. The total magnitude of the tide is estimated by the difference between the height of high and low water. The higher the flood-tide rises, the lower the ebb-tide generally sinks on the same day. At Brest, the medium spring tide is about 19 feet, and the mean neap tide about 9. On other parts of the coast of France and England, the waters being confined, rise to a great height, and at St. Malo it is frequently from 45 to 50 feet; and still higher tides occur at Annapolis, in Nova Scotia, where they are sometimes 70 feet high. It is the obstruction which the land presents to the motions of the waters, that occasions tides of any consequence at all. Were the globe entirely covered with water, the tides would be very insignificant. Thus, in the Pacific Ocean, the spring tide amounts only to 5 feet.

On the other hand, a free communication with the ocean is indispensable to produce a high tide, and in inland seas, the tides are very trifling, because the luminaries act nearly equally over the whole surface at the same time.

The height of the tide increases as the sun or moon is nearer the earth, but in a higher ratio. The rise of the tides is likewise greater when the sun and moon are both nearest the zenith of a place, and less, as they decline from it. When the observer and the moon are on the same side of the equator, the tide which happens when the moon is above the horizon, is greater than when she is below. The reverse occurs when the observer and the moon are on opposite sides of the equator. The cause of this is easily understood from what has been said above. If the tides be considered relatively to the whole globe and to the open sea, it appears that the meridian about 30° eastward of that on which the moon is, has always high water, both in the hemisphere where the moon is, and in the opposite. On the west side of this circle, the tide is flowing; on the east side, it is ebbing; and on the meridian, which is at right angles to the same, it is everywhere low water. These meridian circles move westward, keeping nearly at the same distance from the moon, only approaching

nearer to her when new or full, and withdrawing at the quarters. In high latitudes, the tides are very inconsiderable; and it is probable that at the Poles there are no diurnal tides; but there is some ground for thinking that the water will rise higher at the Pole, to which the luminaries are at any time nearest, than at the opposite.

The great wave which follows the moon, and constitutes the tide, is to be considered as an undulation of the waters of the ocean, in which there is very little progressive motion, except when it passes over shallows, or approaches the shore.

High water occurs, as we said, not when the moon is on the meridian, but from two to three hours afterwards. When the sun is before or west of the moon, he hastens the rise of the tide; but when behind her, he retards it.

Considerable extent of surface is necessary, in order that the sea should be sensibly affected by the action of the sun and moon; for it is only by the inequality of such action on different parts of the mass of waters, that their level is disturbed. In narrow seas, and on shores far from the main body of the waters, the tides are not caused by the direct action of the luminaries; they are waves propagated by the great diurnal undulation. Of this, the tides on the coast of Great Britain, and in the German Sea, are remarkable examples. The high water transmitted from the tide in the Atlantic, reaches Ushant between three and four hours after the moon has passed the meridian, and its ridge stretches north-west, so as to fall a little south of the coast of Ireland. This wave, soon after, divides itself into three branches, one passing up the British Channel, another ranging along the west side of Ireland and Scotland, and the third entering the Irish Channel. The first of these moves at the rate of fifty miles an hour, so as to pass through the Straits of Dover, and to reach the Nore, or mouth of the Thames, about midnight, during spring tides. The second, being in a more open sea, moves more rapidly, reaching the north of Ireland by six o'clock, P. M. About nine o'clock it has reached the Orkney Islands, and forms a wave or ridge stretching due north; at midnight, the summit of the same wave extends from the coast of Buchan, eastward, to the Naze of Norway; and, in twelve hours more, it passes southward through the North Sea, and reaches the Nore, where it meets the morning tide that left the mouth of the Channel only eight hours before. Thus these two tides travel round Great Britain in twenty-eight hours, in which time, the primitive tide has gone quite round the globe, and nearly forty degrees more.

Various curious anomalies are observed in the tides of particular places, such as their ceasing altogether for a day or two, at a certain age of the moon; while, at other times, they become considerable, though perhaps occurring only once a day. It is said, that on some

coasts there is never more than one tide in the course of a lunar day, which is probably owing to some oversight; but it may be shown from theory, that if the observer's distance from the Pole be equal to the moon's declination, he will see but one tide in the day. Small tides occur six times a day, on the shore of the island of Negropont.

The agency of the tides is very extensive in many of the operations of nature, and particularly in those which regard Geology. The late Professor Robison, of Edinburgh, suggested how experiments might be made to determine the mean density of the globe, from the temporary change which is undoubtedly caused on the direction of gravity, by the great body of water brought to Annapolis, and then withdrawn by the stream tides.

The Mediterranean Sea has only very small tides, and these seem to be formed chiefly in the part extending to the east of the island of Malta, and to proceed northward into the Gulf of Venice. The cause of this is the smallness of its surface compared with the diameter of the globe; hence, the moon's action is nearly the same on every part of its surface. The ocean communicates the effect of its tides to such gulfs and inland seas as have their entrances turned towards those points whence the tides come. The Baltic and Mediterranean are not in this situation; hence they are unaffected by the diurnal tide-wave. But Hudson's Bay, and Baffin's Bay, are so; and there, consequently, the tides are sensibly felt. The Arabian Gulf, also, is a striking example of the same kind.

§ XIV.—Marine Currents.

We now proceed to the consideration of those motions of the ocean which from their resemblance to ordinary streams are denominated Currents. It is remarked that between the tropics, and as far as 30 degrees on each side of the equator, there is a continued motion in the waters of the ocean, from east to west, in a direction similar to that of the trade-winds, but contrary to that of the rotation of the globe. Navigators, in order to go from Europe to America, are obliged to descend to the latitude of the Canary Islands, in order to catch the current which carries them rapidly to the west. They observe a similar course in going from America to Asia by the Pacific Ocean. We might imagine that they do this on account of the trade-winds; but they assure us that the effects of the wind are very easily distinguished from those of the marine current. The fact is likewise proved by the direction in which bodies float on the surface of the waters.

A second current flows from each Pole towards the equator.

These have also their corresponding motion in the atmosphere. They are termed Northern and Southern Polar Currents. The most decisive evidence of these motions is deduced from the direction of the floating pieces of ice, which invariably proceed from the Poles towards the equator.

§ XV.—The Polar Currents.

These two currents appear to depend upon the sun, and the rotation of the globe on its axis. They are explained in the following manner. Every day the solar rays dissolve an enormous quantity of ice. Thus the polar seas have always a superabundance of water, which they endeavor to discharge. As the water under the equator has a less specific gravity, and as, moreover, the evaporation, which is very powerful under the torrid zone, absorbs a great part of it, it is necessary that the neighboring waters should flow towards the equator in order to re-establish the equilibrium. This motion is propagated from one region to another; and thus the circumpolar waters are slowly impelled towards the equator. They find their way back in the form of huge clouds and masses of vapor, which are carried towards the Poles by the returning currents in the atmosphere.

§ XVI.—The Equatorial Current.

The motion from east to west, which may be called the Tropical or Equatorial Current, appears to result from the same ultimate causes as the polar currents. For as these latter move towards the equator, they pass to points having a more rapid easterly motion than their previous positions: and as (owing to the *vis inertiæ*) they do not at once acquire the rapid motion of the point to which they have come, their easterly motion is slower than that of the solid bodies around them; and hence they have an apparent westerly motion, just as a person walking westward on the deck of a ship which sails eastward at a more rapid rate, is really moving eastward, although he is apparently walking westward. This apparent motion of the currents becomes more rapid the more they move towards the equator, because the eastward motion of the earth's surface increases at a more rapid rate; so that by the time they reach the parallel of 30° they have a decidedly westward motion. Hence it will appear that the two great ocean currents depend upon the same causes as the corresponding atmospheric currents, though the latter probably assist the former.

The northern polar currents exhibit very remarkable effects. They bring upon the coasts of Iceland such an enormous quantity of ice, that all the northern gulfs of that country are filled with it, though they are often 500 feet in depth. The ice is sometimes raised up so as to form mountains. Some years no ice, but immense collections of floating wood, particularly pines and firs, are cast on shore. It is in the semicircular hollow of the northern coast of Iceland, that the wood and ice are accumulated. It is evident that it is one and the same cause which brings them thither; and as it is impossible that great trees can be produced under the Pole itself, the wood can only come from Siberia or North America. The phenomenon of these floating forests, which are only found in the circumpolar seas of the north, have very much engaged the attention of Geographers, and it is not yet perfectly explained. It is believed that the wood is drifted partly from the Gulf of Mexico, by the current of Bahama, because specimens of timber have occasionally been seen, which grows only in Mexico and Brazil. These kinds, however, are in small quantities. Siberia, and the unknown northern coast of America, contribute probably much greater proportions.

§ XVI.—Double and Opposite Currents.

It is very possible that there may be in the same place a double local current, the one above, near the surface of the water, the other at the bottom. Some alleged facts seem to prove this hypothesis, which was first proposed by the celebrated Halley. In the sea round the Antilles, it is said there are some places where a vessel may moor itself in the midst of a current, by dropping to a certain known depth, a cable to which is attached a sounding lead. If this were so there must unquestionably be a current below, contrary to that which is at the surface of the water. The stationary situation of the vessel would arise from the equality of the two forces, the one acting on the ship, the other on the lead. Similar circumstances are said to have been observed in the Sound; and some suppose that the Mediterranean discharges its waters by an inferior or concealed current.

A difference of density in the beds of water, a great rapidity of motion, and the coherence of fluid particles, are plausible reasons in favor of this hypothesis of Double Currents. But they find little favor among philosophers at the present day; and the facts alleged in favor of their existence are all unsatisfactory.

It is more easy to prove than to explain the existence of opposite currents, which *pass along* by the side of each other. In the Kattegat, *a northern current* proceeds from the Baltic along the coasts of

Sweden; and another, a southern current, enters into the Baltic along the coasts of Jutland. In the North Sea, there is a northern current which comes from the Pas de Calais, or that part which divides the English Channel from the North Sea, and a southern current which goes from the Orkneys along the British coast. The great rivers often occasion currents at their mouths, contrary to those of the sea.

§ XVIII.—Eddies, or Whirlpools.

When two currents of a more or less contrary direction, and of equal forces, meet in a narrow passage, they both turn, as it were, upon a centre, which is sometimes spiral, until they unite, or one of the two escapes. This is what is termed a whirlpool or eddy. The most celebrated are, the Euripus, near the Island of Eubœa, the Maelstrom, on the northern coast of Norway, Corryvreckan, on the western coast of Scotland, and Hurlgate, near New York. These eddies sometimes augment their force by means of two contrary high tides, or by the action of the winds. They draw vessels along, and dash them against the rocks, or engulph them in the eddies, the wrecks not appearing until some time afterwards. Upon this simple ground, very marvellous fables have been invented, and mention has been made of gulfs at the bottom of the ocean, and subterraneous rivers, and other things, the existence of which is quite imaginary.

§ XIX.—Depth, Rapidity, and Direction of Currents.

The depth of currents is a physical problem very difficult to solve. The perpetual currents, however, from their regularity and their powerful action, even in the greatest calms, sufficiently indicate that they have a considerable depth. Their rapidity is not better known. That of the equator is reckoned 10 miles per day. It is independent of winds and waves. But which of these two forces is to be distinguished as that which, acting on the surface, is more sensibly felt by navigators, none can tell.

Currents are either general, arising from the diurnal rotation of the earth about its axis, or particular, arising through accidental and particular causes, such as the waters being driven down against promontories, or into gulfs and straits, where, wanting room to spread, they are driven back, and thus disturb the ordinary course, or flux of the sea. Some currents are variable, directed towards different parts of the ocean, and some are constant, while others are periodical.

As the knowledge of the direction and velocity of currents is a very material point in navigation, it is highly necessary to discover both, in order to ascertain a ship's situation and course with accuracy. The most successful general method adopted among mariners, is the following:—a common iron pot, of four or five gallons' capacity, is suspended by a small rope so as to hang directly upright. The rope, which may be from 70 to 100 fathoms long, is coiled into a boat, which is hoisted out of the ship when there is no wind to ruffle the surface of the sea. The pot being then thrown overboard into the water, and immediately sinking, the line is slackened till 70 or 80 fathoms are run out, after which it is fastened to the boat's stern, by which it is restrained and rides at anchor. The velocity of the current is then easily tried by the log and half-minute glass, the usual instruments for discovering the rate of a ship's sailing at sea. The course of the stream is next obtained by the compass provided for this operation. Having thus found the setting and drift of the current, it next remains to apply this experiment to nautical purposes.

There are a great many shifting currents, which do not last, but return at certain periods. Most of these depend upon, and follow the anniversary winds, or monsoons, which, by blowing in one place, may cause a current in another. Varenius informs us, that in the Straits of Sunda, when the monsoons blow from the west, in the month of May, the currents set to the east—contrary to the general motion. Between Cochin China and Malacca, when the western monsoons blow, from April to August, the currents set eastward, against the general motion; but the rest of the year they set westward, the monsoon corresponding with the general motion. They run so strongly in these seas, that inexperienced sailors mistake them for breakers. In the Straits of Gibraltar, the currents carry ships almost always to the eastward, driving them hard into the Mediterranean. This is the case also in the British Channel.

§ XX.—Currents of the Pacific.

The Pacific Ocean, by its general motion, retreats from the coasts of America, and flows from east to west; and the motion is very powerful in the vast and uninterrupted extent of that sea. Near Cape Corrientes, in Peru, the sea appears to flow from the land. By this single cause ships are carried with rapidity from the port of Acapulco, in Mexico, to the Philippine Isles. But in order to return, they are obliged to go to the north of the tropics, to seek the polar curent and the variable winds. On the other side, the south polar current, finding no land to impede it, carries along with it polar ice, even to

latitudes where the motion of the tropical current begins to be felt. This is the reason why, in the southern hemisphere, floating pieces of ice are met with at 50, and even 40 degrees, S. latitude.

The Pacific Ocean, in its motion towards the west, is impeded by an immense archipelago of flats, islands, submarine mountains, and even lands of considerable extent; it penetrates into this labyrinth, and there forms various successive currents. The direction which the principal of these currents observe, is conformable to the general motion towards the west. But the inequalities of the basin of the sea, the coasts, mountains, &c., turn some towards the north or south. We may easily imagine that a strong percussion of the waters of the ocean, in consequence of their meeting with a large mass of land, such as New South Wales, may even produce a counter current, which will return towards the east, and which, by breaking, will also produce other currents, differently directed. Here, then, is the origin of those dangerous currents which Cook and La Pérouse mention in their voyages.

§ XXI.—Currents of the Indian Ocean.

In the Indian Ocean we shall find the celebrated Perpetual Current, which runs northward from New Holland and Sumatra, as far as the bottom of the Bay of Bengal. This current arises from the pressure of the polar currents upon the large opening which the Indian Ocean presents to the south. This ocean is bounded to the north by the immense Asiatic Continent; the equatorial current which is formed there, is, therefore, feeble, or altogether ceases, as there is no mass of cold water passing from the north. On the other side, the Pacific Ocean cannot carry its impetus thither, as it is broken and dispersed in the labyrinth of islands. Thus, the influence of the southern polar streams predominates, without an obstacle, in the Indian Ocean; and these produce the perpetual current, which sets towards the Bay of Bengal, upon a line more and more inclined towards the north-west, or following the conformation of the coasts.

The action of the general motion of the sea, at first weak, in the Indian Ocean, augments by degrees, till it gains the ascendency. It is easy to imagine, that a general impulse, which acts on a vast fluid, and which influences all its particles, ought to increase according as that fluid extends in the direction of the moving power. One part of the sea, then, reacts upon the other, and the sum of these repeated effects, in time, becomes immense. These principles show why, towards the Island of Java, the natural motion of the sea is changed by the northern current, of which we have spoken; and why this same motion to the west, is found in the neighborhood of Ceylon

and the Maldive Islands. But a new local circumstance again makes this motion decline from its natural direction. A chain of islands and shallows extends from Cape Comorin, in the peninsula of India, to the north point of Madagascar. The principal current being interrupted by these obstacles, turns towards the south-west, and in maintaining that direction, glides along that chain of mountains, some of them submarine, others on the shore. Having passed Madagascar, it turns towards Africa, dashes against that continent, and sweeps, with great violence, the shores of Natal. At the point where the African coast, turning to the west, ceases to present an obstacle to the progress of the water, the current loses all its impetuosity, and mingles with the general motion of the Ethiopean Ocean.

The principal current, or great mass of waters, towards the Maldive Islands, turns to the south-west; but the more superficial currents, and most variable ones, continue their course from east to west; that is, towards the Gulf of Arabia and the coasts of Zanguebar. These are the currents, which, setting towards the south-west, render the Mozambique Channel so difficult to navigate, and which has given the name of Cape *Corrientes* to the cape, upon the coast of Inhambane. They re-unite, at the bottom of this cape, with the perpetual current. We will remark here, that in general, the currents which do not extend to a great depth under the level of the waters, are liable to change with the winds, particularly when they blow for a long time together in one direction, with an equal and constant force, as the monsoons do. These are the winds which give, by turns, opposite directions to the currents which prevail from the Maldive Islands to Arabia and Zanguebar. The shallows and rocks with which these parts are strewed, equally contribute to produce the same effect. The northern current which runs along the Island of Sumatra impels one of its branches through the Straits of Sunda. This current, according to some authors, is the same which La Pérouse found to be of such strength, in the Sea of Japan and in the Channels of Tartary; but these currents appear to vary with the monsoons, and to have no connection with each other. All the southern and northern currents that we observe along the eastern coasts of the continents, are only necessary continuations of the general motion of the ocean towards the west; the waters impelled by this motion towards the eastern coasts of two continents, and finding no outlet, must, with much force, flow along the coasts, in a southern or northern direction, as local circumstances determine them. In Bhering's Straits the polar current, which brings the ice from the Polar Seas to the environs of Kamschatka, is distinctly felt.

§ XXII.—Currents of the Atlantic.

The form of this basin, (whose length is much greater than its breadth,) in a great measure, determines its currents. The first current which we notice is that which carries forward the waters from the Ethiopian Ocean along the coasts of Brazil, and through the Straits of Magellan, into the Pacific Ocean. This course is conformable to the general progress of the ocean.

The most celebrated perpetual current of the Atlantic Ocean, is that which commences on this side of Cape St. Augustin, in Brazil, and extends towards the eastern coasts of America. It is extremely rapid, and is felt in all the extent of sea over which the Antilles are scattered. This current is only the result of the general motion of the Atlantic towards the west, and is only a part of the great trôpical current. It prevails between the 30° of northern and 10° of southern latitude.

Upon the western coasts of Africa, there exists a current directly contrary to the preceding, which is neither less rapid, nor less steady. Ships, if they approach too near these coasts, are drawn into the Gulf of Guinea, and with difficulty extricate themselves. No adequate cause can be assigned for this singular current. Some authors imagine that there are two currents in the Atlantic Ocean, one at the surface, and the other at the bottom; and that it is this latter which brings the waters towards Africa: but such an explanation is inadmissible, from the well-known fact of the general motion of the seas, which is not superficial, but which pervades the whole mass. It is more probable, that the current in question comes from the Straits of Gibraltar, along the coast of Africa only, where the waters have not acquired all the velocity of the general motion; but we can affirm nothing with certainty on the subject.

A third very celebrated current, is that by which the waters of the Atlantic are carried violently into the Gulf of Mexico, and discharging themselves through the Channel of Bahama, run with great velocity towards the north, or rather north-east. This current is well known under the name of the Gulf Stream. It follows the coasts of the United States, becoming wider, and at the same time slower. A zone of 140 leagues, separates it from the equatorial current. The equatorial current impels the waters of the Atlantic Ocean towards the Mosquito shore, and coast of Honduras, in the Caribbean Sea. The new continent opposes this current; the waters flow to the north-west, and passing into the Gulf of Mexico, by the strait which is formed by Cape Yucatan or Catoche, and Cape St. Antonio, in Cuba, they follow the windings of the American coast to the Shalows, west of the southern extremity of Florida. Then the current

turns again to the north, flowing into the Bahama Channel. In the month of May, 1804, Von Humboldt observed in it a rapidity of five feet in a second, though the north wind blew violently. Round the coast of Cape Canaveral, the current flows to the north, and its rapidity is sometimes five nautical miles an hour. This current is known by the elevated temperature of its waters, their great saltness, their indigo-blue color, the train of sea-weed which covers their surface, and by the heat of the surrounding atmosphere, which is very perceptible in winter. Its rapidity diminishes towards the north, and at the same time its breadth increases. Near the Bahama bank, the breadth is 15 leagues; in lat. 28° 30′ N. it is 17 leagues, and under the parallel of Charleston, from 40 to 50 leagues. To the east of the port of Boston, and under the meridian of Halifax, it is 80 marine leagues in breadth. There it suddenly turns to the east, and touches the southern extremity of the great Bank of Newfoundland.

The waters of this bank have a temperature of from 48° to 50° Fahrenheit. The waters of the bank are 16° 9′ colder than those of the ocean, and these are 5° 4′ colder than those of the current. From the Bank of Newfoundland to the Azores, the Gulf Stream flows to the east or east-south-east. The waters preserve, even there, a part of the impulse received in the Strait of Florida. Under the meridian of the islands of Coroo, and Flores, the current has a breadth of 160 leagues. In lat. 33° the equatorial current approaches very near the Gulf Stream. From the Azores, the current flows towards Gibraltar, the island of Madeira, and the Canaries. South of that island, it flows to the south-east and south-south-east, towards the coast of Africa. In lat. 25° and 26° it flows first south, then south-west; Cape Blanc appears to influence this direction, and in its latitude the waters mingle with the great current of the tropics. Blagden, Benjamin Franklin, and Jonathan Williams, first made known the elevated temperature of the Gulf Stream, and the coldness of the Shallows, where the lower strata unites with the upper, upon the borders or edges of the Bank of Newfoundland.

The Gulf Stream changes its direction and place, according to the season. Its force, and its direction, are modified in high latitudes, by the variable winds of the temperate zones, and the collection of ice proceeding from the Arctic regions. A drop of water of the current, would take two years and ten months to return to the place whence it departs. A boat, not acted on by the wind, would go from the Canaries to the coast of Caraccas, in thirteen months; in ten months, it would make the tour of the Gulf of Mexico; and in forty or fifty days, would go from Florida to the Bank of Newfoundland.

The Gulf Stream furnished to Christopher Columbus, indications of *the existence of land to the* west. This current had carried upon

the Azores the bodies of two men of an unknown race, and pieces of bamboo of enormous size. In lat. 45° or 50°, near Bonnet Flamand, an arm of the Gulf Stream flows from the south-west to the north-east, towards the coast of Europe. It deposits upon the coasts of Ireland and Norway, trees and fruits belonging to the torrid zone. Remains of a vessel burnt at Jamaica, were found on the coast of Scotland.

The causes of these currents are very numerous. The waters may be put in motion by an external impulse—by a difference of heat and saltness—by the inequality of evaporation in different latitudes, and by the change in the pressure, at different points of the surface of the ocean.

Such masses of water flowing constantly from the torrid zone towards the North Pole, and at any given latitude, heated many degrees above the temperature of the adjoining ocean, must exert great influence on the atmosphere. An interesting table, in Darby's View of the United States, (Philadelphia, 1828, page 364,) shows this influence in a striking manner. At the same time, the polar currents flowing towards the equator, exert a beneficial influence in cooling the warm regions of the earth.

§ XXIII.—Composition and Properties of Pure Water.

Water, in its pure state, is a transparent fluid, without color or smell. It presents itself under three forms: as a solid, when it is ice, as a liquid, called water, and as a vapor, in which form it is termed steam, or atmospheric gas. Water, in a state of purity, contains by weight, 88.90 parts of oxygen combined with 11.16 parts of hydrogen gas; by volume, it is 2 measures of hydrogen to 1 of oxygen. But we seldom find water perfectly pure, as it generally holds in solution siliceous, calcareous, and metallic particles, acids, and sulphur. It is 815 times heavier than air, weighing 1000 ounces per cubic foot.

Its agency is concerned in all the great operations of nature; and it is indispensable to the support of vegetable and animal life. Like most other substances, water expands by heat, and contracts by cold; but there is a striking exception to this when its temperature is between its freezing point (32°) and 40°, which is its point of greatest density: for as it cools from 40° to the freezing point, it expands, and becomes lighter, so that ice always forms on the surface, whereas if it regularly contracted down to the point of congelation, as all other substances do, ice would always form at the bottom; and all the temperate and frigid regions of the world would become quite barren and uninhabitable, owing to the permanent crust of ice that would

form immediately below the surface of the lands and waters. Water is extremely plastic, and a good conductor of sound; but it is a very bad conductor of heat, and of electricity of low tension.

Although the temperature of 32° is called the freezing point of water, it is only in favorable circumstances that it freezes at so high a temperature. If kept quite still in a perfectly round and smooth vessel, it may be cooled much lower without freezing. But ice always begins to melt at 32°. Under the ordinary pressure of the atmosphere, at the sea level, water boils at 212°; but as the atmospheric pressure is diminished, the boiling point becomes lower, so that under the exhausted receiver of an air-pump, it can be made to boil while it is freezing. Below the sea level, as in some mines, the boiling point exceeds 212°.

Congelation commences in the form of prismatic crystals, crossing each other at angles of 60°, or 120°, and the temperature, however low before, instantly rises to 32°. During this process the water expands with prodigious force, the volume suddenly increasing about a ninth part. Glass bottles filled with water and properly stopped, are burst during congelation, and the same has happened to a strong bomb-shell. Water passes into vapor at all temperatures, and under any pressure. When the elasticity of the vapor equals, or exceeds the incumbent pressure, the process proceeds with violence, and is called boiling.

The relations of water to heat are very remarkable. With the exception of hydrogen gas, it absorbs more heat in warming, and parts with more in cooling, than other bodies do. Hence, large bodies of water have a powerful influence in checking or retarding sudden alterations of temperature in the surrounding air. Ice, in melting, absorbs as much heat as would raise its temperature 140°, and gives out the like quantity again in the act of freezing, a property which enables it to resist or retard sudden alterations of temperature in cold climates, in a very remarkable degree. In assuming the gaseous form, it absorbs heat sufficient to raise its temperature 1000°, and parts with as much during the act of re-condensing into water; hence, it possesses an almost boundless influence in tempering climate. These properties enable us to understand why countries remote from the sea, like Central Asia, have climates remarkable at once for the heat of summer and the cold of winter, while the isles of the ocean are noted for an equable climate.

§ XXIV.—Springs.

Springs are so many little reservoirs, which receive their waters from *the neighboring ground through* small lateral canals, and which

discharge their excess, either by overflowing, or in some other manner.

The vapors raised by evaporation descend in the form of dews, rain, snow, or hail, and form a permanent supply for these reservoirs. These apparently humble sources produce the extensive lakes which are found among mountains, and the terrific glaciers which cover the Alps.

The opinion of the ancients, and of Descartes, who attributed the origin of springs to the filtration of sea water, is now universally rejected by men of science, who have traced them all to the waters which fall from the atmosphere.

It was formerly thought that rain-water did not penetrate to any great depth in the earth, but was entirely absorbed by the first strata of the soil, and that it fell in too small quantities to supply either torrents or rivers. But it has been found to flow rapidly through the interstices and cracks of the upper strata, and does not stop until it arrives at the clayey part of the soils, which is the termination of its filtering, and forms its natural reservoirs. Observation has also proved that rain-water filters down to very great depths. In the coal mines of Auvergne it has been seen to penetrate as far as 250 feet below the surface; and in Misnia, a district of Saxony, it has been known to distil in drops from the roof of a mine 1,600 feet deep. The snows in some countries produce a greater quantity of running water than rain or dews. But in order to understand how much the slow, and gentle, but uninterrupted influence of these latter agents contribute to the formation of springs, we have only to consider Apulia and other peninsulas almost destitute of running water, because their mountains do not constitute a mass sufficient either from their elevation, or bulk, to attract or retain the aqueous vapors of the atmosphere.

On the principle that it is from the sea the atmosphere obtains most of its water, it is easy to explain why the interior of many great continents, like Africa and Asia, contains such barren deserts. If North and South America are more abundantly watered, they owe it to the extent and elevation of their mountains, as well as the continuity of their declivities. The water which circulates on the surface of the globe has generally no other principle of motion than its own specific gravity and the declivity of the earth. It is this declivity that carries it from mountain to mountain, from valley to valley, until it falls into the basin of the ocean.

The spouting springs, which sometimes form natural jets of water, follow the same rules of equilibrium as the others, except that the canals which furnish them with water come from great elevations and with a rapid descent. Waters thus carried into a subterraneous

reservoir, being closely confined, burst forth in consequence of the pressure, just like the fountains which adorn our gardens.

§ XXV.—Periodical, or Intermitting Springs.

The intermitting fountains, particularly such as rise and fall at regular periods, so excited the wonder of observers that they gave them the name of Miraculous Fountains. The periodical fountain of Como, in Italy, has been described by Pliny. It rises and falls every hour. There is another in the town of Colmars, in Provence, which rises and falls every hour. There is another at Fronzanches, in Languedoc, which rises every day fifty minutes later than the preceding day. The round fountain on the road from Pontarlier to Touillon, in Franché Compte, rises with a boiling appearance. The Butterhorn, in Westphalia, rises with a great noise. Near Brest there is a well, 75 miles from the sea, which sinks with the flow, and rises with the ebbings of the sea. England furnishes many examples of these springs, particularly one near Tor Bay, in Devonshire, and one at Buxton, in Derbyshire. According to Gruner, there is one at Engerllez, in the Canton of Berne, which has a double intermission, daily, and annually.

These springs are accounted for by supposing, that in lands where they are situated, there are reservoirs, with conducting pipes in the form of syphons. The water begins to flow through the syphon as soon as the surface in which one end of the tube is placed, is on a level with the bend or highest part; and the flowing continues as long as the fluid keeps above the orifice of the branch inserted into it. The moment the orifice ceases to be immersed in the liquid, the flowing ceases; and it does not begin again till the reservoir is filled to the level of the bend. With respect to the reservoirs which supply these fountains, drought, rain, and the melting of snow, may so affect them as to render their periodical return more or less regular.

The connection subsisting between the greater or less humidity of the atmosphere and the reservoirs of intermitting fountains, justifies, to a certain degree, the conjectures which are sometimes formed from the movements of these springs, as to the nature of the approaching seasons, conjectures which have given to some of them the names of Fountain of Dearth and Fountain of Plenty.

§ XXVI.—Subterraneous and Marine Springs.

Many channels of *water, not* finding any other suitable outlet, flow *into subterraneous cavities*, are absorbed by the earth, or discharge

themselves below the ground, into the sea. This is the origin of those springs of fresh water that are to be seen spouting up, even in the midst of the waves of the ocean. These sometimes furnish the mariner with fresh water. In other places, they do not come to the surface, but afford their fresh water only to divers. Many of those springs do not differ essentially from common springs. That a reservoir of water should find an outlet below the level of the sea, is not in reality more surprising than that it should find an outlet above that level. Hence, the surprise excited by seeing fresh water bubbling up from the bottom of the sea, amidst the briny waves, is to be attributed to its novelty, and the thoughtlessness of the beholders. Submarine springs are, in all probability, exceedingly numerous; but it is only in certain circumstances that they are likely to be discovered; and hence the number of those that are known, probably bears only a small proportion to the whole. To the class of subterraneous springs may be referred those which rise in caverns: these delight us by their picturesqueness, and the many poetical associations to which they give rise.

§ XXVII.—Hot Springs.

Hot springs are those whose waters are warmer than the mean temperature of the place. Such as are merely tepid, are common in most countries, especially near or within mines. Those having a considerably higher temperature, are less frequently met with, and mostly in volcanic districts. Some of these reach the boiling point, spouting forth with great violence, actually boiling, which indicates their having had a still higher temperature before they found vent. The most remarkable are the hot springs of Iceland.

Although the hot springs of this country are more abundant than in any other region, the interest which their number and variety excites, is lost in the feelings which arise on beholding the magnificent and tremendous explosions of the great Geyser and its counterparts. Besides the large fountains, there is a great number of boiling springs, cavities full of hot water, and several from which steam issues. There are also some places full of boiling mud, of gray and red colors. The siliceous depositions of the waters of the great Geyser have formed for it a basin 56 feet in diameter, in one direction, and 46 in another, (a projection from one side causing it to deviate from a perfect circle,) with a depth of 75 feet. In the centre of this basin, is a cylindrical pit, or shaft, 10 feet in diameter. Through this the hot water rises, gradually filling it and also the basin, and runs over in small quantities. At intervals of some hours, when the basin is

full, explosions are heard from below, like the report of distant cannon, and at the same moment a tremendous motion of the ground is felt all around the basin. Immediately the water rises in a mass from the pit, and, sinking again, causes the water in the basin to be agitated and to overflow. Another, and a stronger propulsion follows, and clouds of vapor ascend. At length strong explosions take place, and large quantities of steam escaping, the water is thrown to a height of from 30 to 90 feet, and even to 200 or 300 feet. The steam, coming into contact with the cold atmosphere of that climate, is condensed into thick clouds, which are tossed and rolled about, forming a magnificent exhibition. The explosions cease after some time, and then the basin and pit are found empty. Bursts of steam sometimes take place, when the water is rising, without any warning by subterraneous noise. These phenomena seem to be occasioned by steam, finding its way from below into cavities, where part of it is condensed into water, which is forced out by the action of the steam under high pressure. The temperature of the Great Geyser is sometimes as high as 260°.

The new Geyser is smaller than the other, and called *Little Geyser.* There are many hot springs in Iceland, but that of the Tunghaer is the most curious of all. Among a great number of boiling springs are two cavities within a yard of each other, from which the water spouts alternately. While from one the water is thrown about 10 feet high, in a narrow jet, the other cavity is full of water boiling violently. This jet continues four or five minutes, and then subsides, when the water of the other immediately rises in a thicker column, to the height of three or four feet. This lasts about 3 minutes, when it sinks, and the other rises; and so on. Some springs emit inflammable matter, which burns like ardent spirits, on the application of a light. This generally arises from naphtha, or petroleum, floating on the surface.

It has been observed, that the greatest number of hot and warm springs occur in volcanic countries, where volcanoes were formerly, or are still in a state of activity. Of those that do not occur in volcanic districts, some are associated with trap and granite rocks, to which geologists assign an igneous origin. Hence, it is inferred, that such springs owe their temperature to the same causes which give rise to volcanic and igneous rocks. That the heat of such springs is often connected with volcanic action, cannot admit of doubt; for, from the Geyser of Iceland, the transition is almost uninterrupted to the hot springs, in the dormant volcano, in the Island of Ischia. The hot and warm springs of Bath and Bristol, however, occur in a limestone country, where no igneous rocks are visible; but these may lie under the limestone. This opinion is further countenanced, by the fact, that many of the hot springs met with in primitive, and

also in secondary formations, occur in spots where the strata appear to have been disturbed by igneous agency. Of this there is a striking example in the hot springs of Carlsbad in Bohemia. The hot springs of Clifton, in England, issue from a limestone, which appears to have been disturbed at an early period by igneous action. The hot springs of Pfeffers, in the Grisons, gush from a ravine, from 400 to 654 feet in depth, and so perpendicular, that the provisions required for the inmates of the bath, are lowered from ropes attached to the summit of the cliff, and so narrow, that the rocks, in some places, touch overhead, and nowhere, perhaps, are more than 30 feet apart. The most obvious explanation of this phenomenon is to be found in some convulsion of nature, such as that caused by an earthquake, or the sudden elevation of a large tract of country.

The other hot springs in Switzerland appear in similar circumstances. Those of Weissenburg, in Berne, rise out of a gorge, like that of Pfeffers; those of Louechi appear at the foot of the mural precipice of Gemmi; while the spring of Baden, in Argovia, from which that of Schinezath is not far removed, lies near the point where the two mountains of Staffelegg and Lagern have been severed by some great convulsion.

TABLE OF THE PRINCIPAL HOT SPRINGS.

Name.	Country.	Temperature.
San Pedro,	Portugal,	154°
Chaves',	"	142°
Vic,	France,	212°
Plombières,	"	154°
Vichy,	"	115°
Bourbons Les Bains,	"	156°
Bourbon L'Archambaud,	"	140°
Chaudes Aigues,	"	190°
Teplitz,	Austria,	113°
Carlsbad,	"	165°
Wiesbaden,	Nassau,	158°
Aix La Chapelle,	Prussia,	136°
Baden,	Baden,	154°
Piscarelli,	Naples,	200°
Geyser,	Iceland,	212°
Buxton,	England,	82°
Bristol,	"	74°
Bath,	"	117°
St. Michael,	Azores,	208°
Hot Springs,	Arkansas,	212°

Name.	Country.	Temperature.
Hot Springs,	Virginia, ...	112°
Warm Springs,	North Carolina, . . .	104°
Sweet Springs,	Virginia, ...	73°
Sans Souci,	New York, ...	50°
Chichimaquillo,	Mexico, ...	205°
St. Lucia,	West Indies, ...	203°
Eaux Bouilli,	Martinique, ...	131°
Puoto,	Venezuela, ...	112°
Trincheras,	"	195°
Cuença,	Ecuador, ...	162°

§ XXVIII.—Mineral Springs.

Springs in their course through the earth often dissolve minerals; and thus produce a great variety of mineral springs. These contain salts, earths, acids, metals, and inflammable matters, the ingredients depending on the nature of the materials with which they come in contact. The quantity of mineral matter brought from the interior of the earth by springs is very great.

Even some calcareous springs in Britain deposit annually vast quantities of calcareous tufa and sinter. In the neighborhood of Edinburgh, there are great calcareous deposits, from calcareous springs, that now flow through limestone rocks, and appearances of the same kind abound around all the calcareous springs in England. Near Clermont, in France, some calcareous springs rise through rocks of granite and gneiss, and have formed a hill 240 feet high. Many of the great edifices in Rome, are built of calcareous deposits of this kind. The hot springs of Iceland and the Azores annually deposit great quantities of silica. Salt springs also bring from the interior of the earth, and spread over their vicinity much salt, which may be derived from the saline clays and salt beds through which they pass; or may come from a great depth as an igneous production.

Mineral waters are unfit for common use, their ingredients giving them a sensible flavor, and a specific action upon the animal economy. They are very various, both in their composition and temperature, and in their effect upon the system; and are generally so far impregnated with acid or saline bodies, as to derive from them their peculiarities. They are commonly divided into four classes,—acidulous or carbonated, saline, chalybeate or ferruginous, and sulphureous. With regard to temperature, they are also divided into warm, or thermal, and cold. The substances which have been found in mineral waters are very numerous; but those which most frequently *occur, are oxygen,* nitrogen, carbon, and sulphur, in *different combinations;* lime, iron, and magnesia.

Mineral waters are sometimes produced in the laboratories of chemists, either by a combination of the same ingredients, so as to imitate natural waters, or by producing different combinations, so as to form compounds not known to exist in nature.

The saline springs consist in general of salts of soda and lime, or of magnesia and lime, with carbonic acid, and oxide of iron. The principal saline springs are those of Pyrmont, Seidlitz, and Epsom.

The chalybeate or ferruginous waters have a decided styptic taste, and are turned black by an infusion of gall-nuts. Their principal mineral is iron, either in the state of an oxide, held in solution by carbonic acid, or as a sulphate, although sometimes it is found in both forms in the same water. The waters of Vichy, Spa, Forges, Passy, Cheltenham, and Tunbridge, in Europe, and Bedford, Pittsburg, and Yellow Springs, in the United States of America, are the most celebrated of this class.

The acidulous waters are characterized by an acid taste, and by the disengagement of fixed air. They contain five or six times their volume of carbonic acid gas. The principal salts which they contain are hydrochlorates and carbonates of lime and magnesia, and carbonate and sulphate of iron. The waters of Bath, Buxton, Bristol, Vichy, Seltz, and New Lebanon, are among the most noted of this kind.

The sulphureous waters are easily recognized by their disagreeable smell and their property of tarnishing silver and copper. The springs at Saratoga, Ballston, Harrowgate, Moffatt, Aix La Chapelle, and Aix, are the most celebrated of this class.

When springs contain a great quantity of carbonic acid, they become more grateful to the taste; and when iron is present, as is sometimes the case, they become tonic and stimulant in their effects.

The exact chemical composition of mineral waters is not easily ascertained, as it is frequently very difficult to determine whether a certain product is not the result of the steps employed during the analysis.

§ XXIX.—Origin of Springs.

There are many theories respecting the origin of springs, most of which differ in their deductions and principles, but the only one which seems to be rational and consistent with facts is that of Dr. Halley, who maintains that springs are nothing more than a part of the water which falls on higher ground, filtrating through, and afterwards issuing forth at a lower level. The water at first collects in large subterraneous cavities, from which it afterwards filtrates slowly, and passes towards the springs. The disposition of the rocks, in

strata, contributes much to the collecting of the waters under the surface, and conveying them without waste, as if in close pipes, till they are united in fountains, lakes, and rivers. Dr. Halley showed that the evaporation of the sea alone is a sufficient supply for all the waters that the rivers carry into it. But his calculations are complex. Buffon took a more simple view of the matter by selecting one of those lakes that send out no stream to the ocean, and showing that the probable evaporation from the surface of the lake is equal to all the water carried into it. The internal reservoirs from which springs are supplied, are, in many cases, derived from the water which the earth absorbs from rains and melted snow. From these reservoirs, the water flows out by minute fissures in the sides of the hills. When we see springs rising up in plains, the water flows under ground from distant elevations, and rises, owing to the tendency of a liquid to find its level. We never find a spring on the top of a mountain, nor in any place except where there is higher ground from which it may flow; and when we remember that the annual fall of rain varies little from year to year, we can readily see why springs should be perennial.

§ XXX.—Glaciers.

Glaciers consist of snow which has been partly melted and afterwards frozen. Snows accumulate on mountain tops and in elevated valleys for whole centuries, being compressed and consolidated by alternate thaws and frosts, till they assume the appearance of immense fields of ice. Thus are formed those wide expanses of frozen snow which cover whole mountains. The high valleys are filled at the same time, partly with snow which falls there, partly with the icy waters which flow from the snowy summits, and consolidate these snows, and partly with the avalanches which roll from the overhanging summits. These masses seem, in several instances, to have been increasing for a long series of years. In Switzerland they have filled up whole valleys, buried villages, and closed up passes. But the diminution produced on the lower side by the heat of summer, usually compensates for the increase which they receive on the upper. A few warm seasons are sufficient to re-establish the equilibrium.

The scenes which these bodies of ice exhibit are as varied as their extent, and as beautiful and grand as imagination can conceive. At one time they resemble a great mass of waves; at another, these inequalities disappear, and leave nothing to the eye of the astonished traveller but an immense mirror of polished ice. Here they exhibit superb portals of crystal, and there brilliant spires of sparkling gems. In other places avalanches glide over a field of ice, and

then stop, and reflecting the rays of the sun, display dazzling forms of towering pyramids and obelisks.

Glaciers are of essential service in furnishing water to the surrounding lands; for without this congelation it would be at once precipitated with impetuosity from the mountains, so as to overflow and devastate those countries which it now fertilizes, and leave them afterwards to suffer from protracted droughts. But the cold converts the water into snow and ice, and thus holds it suspended on the sides of the mountains, to supply unfailing and abundant streams, oozing from the base of these enormous masses, or from the bosom of their crystal grottoes.

The position of the snow line, or limit of perpetual snow, depends so much upon variable causes, such as the form of the summits, the comparative altitude and physical features of the surrounding country, the particular exposure of the mountains, etc., that no general rule can be given for determining it in any given latitude.

The ice of the glaciers is different from that of sea and river water. It is not formed in layers, but consists of little grains of congealed snow; and hence, though perfectly clear, and often smooth, it is not transparent. Its fracture is not radiated like that of sea ice, but granular. In the numerous fissures, it has a green hue near the surface, and at the bottom a blue tinge. Along the edges of the glaciers are generally found *moraines*. These are an accumulation of earth and stones, which is often several fathoms high, and in summer present the appearance of bottomless morasses, producing no vegetation. It is probable that these moraines are produced by the avalanche of the glaciers, which roll before them, as they advance, every obstacle that impedes their progress.

The great ice fields, during the summer, slide lower down into the valleys, where they are partially melted by the warmer temperature. In Lapland, where the sun has less power, glaciers slide down into the lower parts of the valleys, and render the air so cool that the line of perpetual snow extends as low as 3,000 feet above the level of the sea. The descent of a glacier is greater or less according to its declination. This is shown by the changes in the position of large masses of rock around it, which are evidently pushed along by its edge. In Switzerland, stones have been found thus pushed forward 25 feet in one year. Stones of considerable bulk are also seen in the moraines, of an entirely different formation from those of the valley, and must therefore have been pushed down from the higher regions in the course of time.

As glaciers, in some positions, and in hot summers, decrease, so they often also increase for a number of years, to such an extent as to render a valley uninhabitable. Their increase is caused chiefly by rnate thawing and freezing, since water expands greatly in the

act of freezing, and the hollows in the mass are frequently filled up by rains or melted snows before the next frost.

Avalanches are nothing but fragments of glaciers which have been broken off owing to the steepness of the slope down which it is moving, or to its being extended over the edge of a precipice. They are sometimes so large as to destroy several villages. Sometimes they carry stones and earth with them as they roll along. When a glacier breaks, it often produces a noise like thunder. The fissures often deceive the traveller by being covered with snow.

In the Tyrol, in Switzerland, Piedmont, and Savoy, the glaciers are so numerous that they have been calculated to form altogether a superficial extent of 1,484 square miles. There are glaciers in Savoy more than 14 miles long, 2 miles wide, and from 60 to 600 feet thick. One of the most famous glaciers, is the Mèr de Glace, or Sea of Ice, in the valley of Chamouni, 5,700 feet above the level of the sea. In France, near Beaume, and in the Carpathian Mountains, near Dselitz, are glaciers which never melt, because they are so situated that the sun cannot act upon them. No glaciers are found in many elevated and snowy regions between the tropics, because the temperature continues the same during the whole year.

§ XXXI.—Origin and Course of Rivers.

The effusion of springs, and the flowings of melted ice, form little currents, more or less gentle, which are termed *rivulets.* The water of heavy rains often produces more impetuous streams, which sometimes furrow the sides of the mountains. The union of these streamlets forms *brooks*, which, following the declivity of the ground, unite most frequently in a great stream, which takes the name of *river*, and which conveys the collected waters to the ocean. The declivities whence flow the streams which discharge themselves into one particular river, are called the *basin* of that river. The basins of two rivers are frequently contiguous; those of the Orinoco, and the Amazon, are actually united by the Cassiquiari, and some others. In Europe, the sources of the Duna, Niemen, and Borysthenes, nearly meet together in a marshy plain. Geology has been much employed in investigating the subject of basins. In general, the mineral beds and petrifications of the same basin present a certain analogy. The elevation of the sources determines the amount of the declivity of streams, and this latter circumstance modifies their course, rendering it rapid or gentle, regular or meandering.

Most of the large rivers originate in mountain ranges; but this is by no means uniformly the case. In the centre of European Russia, *for example, several of the largest* rivers in Europe originate. Yet

there are no mountains around their sources. Between the sou of the Niemen and the Duna, on one side, and those of the Dnie and the Dniester, on the other, there is no sensible elevation; a instead of the mountains laid down there by some geographers, tl is only a marshy plain. Sometimes, as a river advances, the rounding country rises, instead of declining. Thus the Dnieper fl through a deep fissure or glen, through a country more elevated t the marsh in which it rises; and the Niemen passes round some l still more elevated, although its source is on a level with that of Dnieper.

The beds of rivers are the lowest chasms formed by the s revolution which produced the mountains. The streams evide bring down portions of the soil from the sides of the mountains, form, by their sediments or settlings, those horizontal plains wl occupy the bottom of certain valleys; but a river could never, b own force, have opened to itself a passage through solid rocks, sin to those which border on the Upper Rhine: it must first have fo the outline of its course deeply marked out.

Running waters unceasingly wear away their beds and bank places where the declivity is very rapid; they hollow out and de their channels in mountains composed of rocks of a moderate h ness; they draw along stones, and form accumulations of then the lower part of their course; and their beds are often elevate the plains, while they are deepened and depressed in the mount These changes, going on for thousands of years, could only give t to the banks of rivers, but did not create them.

It is only the sloping of the land, which can at first cause rive flow; but an impulse having been once communicated to the n the pressure alone of the water will keep it in motion, even w there is no declivity. Many great rivers flow with an impercep declivity. The river of the Amazons has only 10½ feet of decli upon 200 leagues' extent of water; making $\frac{1}{31}$ of an inch for e 1,000 feet. The Seine, between Valvins and Sevres, has only 1 declivity out of 6,600; the Loire, between Donilly and Bria foot in 75,000. Hence, we see the reason why one river may re another nearly as large as itself, without any great enlargemen its bed. The increase of its quantity, only accelerates its co Sometimes one river, falling into another with great rapidity, ar a very acute angle, will force the former to retrace its course, return for a short space, towards its source. This has happ more than once, to the Rhone, near Geneva. The impetuous A coming down from the mountains of Savoy, being swollen be its usual size, has driven the gentle waters of the Rhone back the lake of Geneva, causing the wheels of mills to revolve l wards.

Some rivers have no stream whatever, and the cause is easily discovered; the land, having scarce any declivity, does not impart a sufficient impulse to their waters, which are constantly retarded, and finally absorbed by the land. Sometimes these river waters are evaporated by the heat of the sun—as is the case with some of the rivers of Arabia, and Africa; but they more commonly flow into pools, marshes, or salt lakes. Thus, we see that declivities are indispensable to the course and flow of rivers, which require a gentle, but steady impulse, to conduct them to the sea. Some rivers suddenly disappear by flowing into subterraneous channels.

When a river is obstructed in its course by a bank of solid rocks, and finds beneath them a stratum of softer materials, its waters wear away the softer substance, and thus open for themselves a subterraneous passage, more or less long. Such are the causes which have formed the sinking of the Rhone, between Seyesel and L'Ecluse, the natural bridge of Veja, near Verona, with an arch of 114 feet; and the magnificent rock bridge in Virginia; an astonishing vault, uniting two mountains, which are separated by a ravine of 270 feet in depth, through which Cedar Creek flows. It is probable that the fall of a rock has formed these natural bridges, like those of Icononzo, in Mexico. In Louisiana, whole forests have been observed to fall on a river, covering it over with vegetable earth, and giving rise to a natural bridge, which, for leagues, obscures the course of the river from sight. The river Guadiana, in Spain, has its waters scattered and filtered in the sandy and marshy grounds, from which they reissue in greater abundance. Many rivers appear to have been at first a series of lakes and cataracts alternately, through which the water was conveyed from higher to lower ground. The bottoms of these lakes were gradually filled up with débris, their outlets by degrees deepened, or the basins rent through. The lakes, at length, became dry plains, traversed by the rivers and the cataracts, clefts, or deep ravines; and the rivers acquired a pretty uniform descent. There are traces of these revolutions to be seen in every part of the globe. The Parallel Roads of Glenroy, in Scotland, are nothing but horizontal shelves, which usually surround lakes. From these it appears that the valley was formerly the basin of a lake, which is now cut through and emptied. Three distinct basins are discovered in the course of the Rhine: first, that of the Lake of Constance; second, that which reaches from Basle to Bingen; the third, from this to the sea. They are separated from each other by rocky straits. In many cases the subsidence of the water, at successive stages, can be traced from one level to another, by means of the different horizontal shelves still visible on the sides of the valleys, as in the case of Glenroy, just mentioned. In the valley of the Rhine, Professor Playfair distinguished four or five terraces, at the successive heights of twenty,

thirty, and forty feet, above one another. The same thing occurs on the banks, in the great chain of North American lakes, not yet empty.

The larger rivers are, the smaller generally is their fall, or declivity. The reason of this is, that there are few materials of which beds of rivers are formed, that could have resisted the action of a great river, having a rapid fall, during the lapse of ages.

§ XXXII.—Cataracts and Cascades.

Rivers which descend from primitive mountains into secondary lands, often form cascades and cataracts. Such are the cataracts of the Nile, the Ganges, and some other great rivers, which, according to Desmarets, evidently mark the limits of the ancient land.

The most picturesque falls are those which are made by rapid rivers, bordered by rocks and trees. Sometimes we see a body of water, which, before it reaches the bottom of the ravine, is broken and dissipated into showers, like the Staubbach. Sometimes it forms a watery arch, projected from a rampart rock, under which a person may pass dry-shod, as the Falling Spring, in Virginia. In one place, we see a river urge on its foaming billows among pointed granitic rocks; in another, amidst lands of a calcareous formation, it rolls down majestically from terrace to terrace, and presents occasionally a fine liquid mirror, and at other times, a wall of water.

The elevation or height of cataracts has generally been exaggerated; that of Tequendama, formed by Rio de Bogota, being only estimated at 600 feet by Humboldt, instead of 1,500, which it was said to be by Bouguer. The cataract of Staubbach, the highest cataract known, instead of being 1,100 feet, as travellers have supposed, is only 900 by trigonometrical measurement.

When the ground does not form a steep and almost perpendicular bank, but only a very rapid declivity, and when, at the same time, the bed of the river is confined by rocks, the waters acquire by compression an astonishing force. Winterbotham relates, that the Connecticut River, in the United States, at 40 leagues from its source, is so compressed with rocks, that it carries along on its surface pieces of lead, as if they were so many corks; and that notwithstanding the utmost efforts, it is impossible to insert an iron point into its waters.

The small river of Ache in Bavaria, which rises in a cavern of the glacier of Mount Tauren, throws itself over an elevation of 2,000 feet. It has five great falls, the last of which forms a most magnificent arch of waters, which is dissolved in spray before it reaches the ground. The noise of its waters is heard at a distance of more than 3 miles; and the current of air produced by the

descent of its waters is so violent that those who attempt to approach the gulf are forcibly driven back. The most celebrated fall in the world is that on the River Niagara, which connects Lake Erie with Lake Ontario. The river, just above the falls, is divided by Goat Island into two parts; one, 600 feet broad, falls to the depth of 150 feet, while the other, 35 yards broad, falls 164 feet, perpendicular height.

In Scotland, the most considerable falls are those of the River Clyde, near Lanark, where the river is precipitated down three successive precipices. In the upper falls, that of Boniton, the river throws itself down a precipice 30 feet high; lower down, at Corra Linn, it is precipitated from a height of 84 feet. The lowest fall, that of Stone Byres, consists of three stages, being broken by two projecting rocks; its fall is 80 feet. On the river Foyers, near Loch Ness, there are two falls, the upper one 40 feet high, the lower 90 feet. In the mineralogical report of Lapland, presented to the Swedish government, the discovery of a great waterfall in the river Lattin is particularly mentioned. It is said that this is half a mile broad, with a fall of four hundred feet.

When a river bed suddenly changes its level, so that the stream is plunged down a considerable distance at once, a cataract, cascade, or fall, is formed; when the change of the level is less abrupt, and the inclination is such as to render the current violent and broken, we give it the name of rapids. "Cataracts," says Lamouroux, "must have been both more numerous and more lofty in the ancient world than they are at present. They are daily diminished, both in number and height, by the action of that universal leveller time; and perhaps, in some future age, the cataracts of the Nile, and the Ganges, the Falls of Niagara, and the cascades of Tequendama, will be looked upon as a fiction of poetry." The Falls of Niagara have been found to be gradually receding from Lake Ontario. This great body of water is hurled over a ledge of hard limestone, below which is a layer of soft shell, which decays and crumbles away, so that the superincumbent limestone is left without a foundation, and falls from time to time in large masses. The bed of the river, below the falls, is strewed over with huge fragments, that have thus been detached and plunged into the abyss. Within the last forty years, the falls have receded nearly fifty yards; and there is little doubt that they were once at Queen's Town, about seven miles below their actual site. Should they continue to recede at the rate above stated, or a little more than one yard annually, it will be 30,000 years before they reach Lake Erie.

Some of the most beautiful cataracts have been created, at least in part, by human labor. The celebrated Cascata del Marmore, at *Terni, "which," says Byron,* "is worth all the cascades and torrents

in Switzerland put together," is attributed to a work of Curius Dentatus (290 B. C.,) who caused the rock to be cut through for the purpose of draining the marshes and making an outlet for the Velino.

Some cataracts owe their celebrity to the vast volume of water which is poured in an unbroken sheet over a great descent, as with the Niagara. Others are remarkable only for the vast height from which they fall, whether they plunge down the abyss at a single leap, or dash themselves successively from shelf to shelf, till they reach the bottom of the precipice. Some, falling in small riband-like currents over the edge of the rock, are dispersed before they reach the ground in small thin spray, forming glittering showers of brilliants or gaudy rainbows; others, driven forward by the force of the current, fall over in a continuous arch, between which and the bottom of the ledge from which they have fallen, the visitor may pass; and yet others are visited and admired chiefly for the picturesque beauties of their site, the grandeur of the precipices, or the gloomy horrors of the deep chasms which surround them. "If it be difficult," says Humboldt, "to describe the beauties of cataracts: it is still more difficult to make them felt by the aid of the pencil." The impression they leave on the mind of the observer depends upon the occurrence of a variety of circumstances. The volume of water must depend upon the height of the fall, and the scenery around must wear a wild and romantic aspect. A cataract surrounded by hills produces much less effect than the water-fall which rushes into the deep and narrow valley of the Alps and Appenines, or still more of the Andes. Independent of the height and body of water, much of the beauty incident to a cataract depends upon the adjacent landscape, the precipitous rocks, the richness of the scenery which surrounds it, and even upon the nature of the trees which clothe its craggy heights. The Niagara Falls, for instance, would be more impressive in their character, if palm trees and other Oriental productions relieved the eye, and lent to the imagination the hues of a lovelier sky, which would contrast happily with the sterile grandeur which now only strikes to appal both the mind and the sense. The great body of the water in this cataract passes the precipice over which it falls with such violence that it forms a curled sheet, which strikes the water below, 50 feet from the base of the precipice, and visitors can pass behind the sheet of water. It is often adorned with a rainbow, and sometimes three are seen in the clouds of spray, which rise 100 feet above the precipice.

The primary regions of Europe abound in cataracts. The torrents are seldom of great size, but the rocky beds over which they roar and dash in foam and spray, the dark glens into which they rush, and the wildness of the whole scenery, often produce strong emotions.

The English language has more terms than any other to express the different degrees of rapid and sudden descent in streams of water. A considerable declivity in the bed of a river produces *rapids;* when it runs down a precipice it forms a *cataract;* and if it falls from steep to steep, in successive cataracts, it forms *cascades.* In primary and transition countries, rivers generally abound in rapids: they also occur in secondary countries, but the descent is more gentle. In alluvial districts falls are very rare: they are most frequently found in the passage of streams from the primitive to the other formations. Rapids and cataracts are often great blessings on account of the water power they afford.

TABLES OF SOME OF THE MOST REMARKABLE FALLS IN THE WORLD.

I. FALLS IN EUROPE.

	Height.
The Orco, Mount Rosa, Italy,	2,400 feet.
Gavarnie, France, Pyrenees,	1,350 "
Fugloe, Isle of Fugloe, Norway,	1,000 "
Staubbach, Switzerland,	960 "
Doby Myllin, Wales,	900 "
Ginfael, Wales,	900 "
Riuken Fossen, Norway,	800 "
Holmess Falls, Scotland,	800 "
Nant Darpenaly, Savoy,	800 "
Maamelven, Norway,	800 "
Serio, Lombardy,	500 "
Lattin Falls, Swedish Lapland,	400 "
Staubbach, Berne, Switzerland,	900 "
Tosa, Valais,	400 "
Gray Mare's Tail, Scotland,	350 "
Terni Velino, Roman State,	300 "
Acharn, Scotland,	240 "
Foyers' Falls, Scotland,	212 "
Reichenbach, Switzerland,	200 "
Tendon, France,	120 "
Kerka, Dalmatia,	100 "
Devil's Bridge, Scotland,	100 "
Gotha Falls, Trolhatta, Sweden,	100 "
Schaff hausen, Switzerland,	70 "
Tivoli, Italy,	50 "
Caldron Linn, Scotland,	88 "
Bruar Falls, Scotland,	70 "
Lynn Ogwen, Wales,	100 "
Cownand Mawr, Wales,	60 "

II. FALLS IN AMERICA.

	Height.
Niagara,	170 feet.
Tesquendama, New Grenada,	580 "
Pusambio, or Purace, New Grenada,	400 "
Montmorency, Canada,	250 "
Falling Spring, United States,	200 "
Catskill, United States,	175 "
Tauquanic, United States,	160 "
Great Falls, United States,	150 "
Chaudière, Canada,	100 "
Missouri, United States,	90 "
Guanacualto, Mexico,	80 "
Passaic, United States,	70 "
Cahoes, do.	60 "
St. Anthony, do.	40 "
Glenn's, do.	40 "
Mississippi Falls, do.	40 "
Missouri Falls, do.	87 " 47 " 26 "
Tochoa Falls, do.	187 "

III. ASIATIC FALLS.

	Height.
Garispa, Indian Ghauts,	1,000 feet.
Birra Chuki,	100 "
Bilohi,	400 "
Ganga Chuki, Cavery,	200 "
Chachai, in India,	362 "
Booti, do.	400 "
Tonse, do.	200 "

There are many beautiful and magnificent falls, not given in the above tables, because they have never been measured.

§ XXXIII.—Periodic Increase of Rivers.

The periodic rise of the Nile used to be considered a singular phe*nomenon, and one* of the greatest mysteries of nature, until modern

Europeans, by penetrating into the torrid zone, which was almost unknown to the ancients, discovered that this wonderful property belonged to many other rivers besides the Nile. It is now well known, that in all countries situated between the tropics, it rains incessantly and heavily, during a certain season of the year, according to local circumstances. The torrid zone, deprived in a great measure of the benefit arising from snows and glaciers, has this deficiency supplied by copious torrents of rain, pouring down incessantly for some time upon the ground that has been almost burnt up with heat during the dry season: then all the lakes and rivers swell and overflow their banks. If a river, under the influence of these tropical rains, flows along a plain, in a direction parallel to the equator, its overflowing waters will spread, with a certain degree of equality, over the whole extent of its banks. Such is the case with the Orinoco, in America, the Senegal, and probably the Niger, in Africa. If, on the contrary, such a river flows from a great elevation, into low plains and valleys, or if its direction be perpendicular to and from the equator, then the action of the tropical rains upon it, will be extremely unequal, for the surplus of water will be carried almost entirely towards the lower parts of its basin. This is exactly what happens in the floods of the Nile. This river undoubtedly rises in the Mountains of the Moon, which probably form a very elevated plateau in the centre of Africa.

In Asia, the rivers Siam and Cambodia flow in nearly the same latitudes as the Nile, but in a different direction, being from north to south. These two rivers have floods resembling the Nile. The Ganges, the Indus, and in general all the rivers which flow between the tropics, present this phenomenon, varied by local circumstances. The rivers beyond the torrid zone are subject only to the less-marked periodic swellings, which arise from the melting of the snow in the spring, and the fall of the autumnal rains.

§ XXXIV.—Mouths of Rivers.

Rivers, in running into the sea, present a great variety of interesting phenomena. Many form sand banks, as the Senegal and the Nile; others, like the Danube, rush with such force into the sea, that for a certain space, the waters of the river can easily be distinguished from those of the sea. Those of Syre, in Norway, are discernible for six miles after they enter the sea. It is only by a very large mouth, like that of the Loire, Elbe, or La Plata, that a river can tranquilly mingle with the sea. Even these, however, feel the influence of the sea, which repels their waters back into their beds. Thus, the Seine, at its mouth, forms a bar of considerable extent; and, the

Garonne, being unable, when opposed by the tide, to discharge its waters with sufficient rapidity, forms, between Bordeaux and its mouth, a kind of gulf, rolling backwards, inundating the banks, and stopping vessels in their progress, both up and down. This phenomenon, termed the *mascaret*, is only the collision of two bodies of water, moving in opposite directions. We have already mentioned the sublime phenomenon of this kind, presented by that giant of rivers, the Amazon. Twice a day the flowing tide resists its imprisoned waves, in their course to the ocean. The shock is sometimes tremendous; and a liquid mountain is raised to the height of 180 feet. The first or second day after every new and full moon, the tide is unusually strong; and the river also seems to redouble its energy; and its waters, and those of the ocean, rush against each other with extreme violence. The banks of the river are inundated with their foaming waves, and loud roarings echo from island to island. The Indians call this phenomenon the *pororoca*.

§ XXXV.—Inundations.

The overflowing of a river is liable to vary at different periods. Thus, it is distinctly mentioned in the Bible, that the Jordan overflowed its banks during harvest, expelling wild animals that lurked in their thickets; but this river does not now overflow its banks. It is said that the channel has become deep enough to hold the floods. But it is not unlikely that its banks have been raised by successive deposits of mud, or it may be that the fall of snow and rain upon Mount Lebanon, whence the floods came, is not so abundant since its forests of cedars have been cut down; for some travellers are of opinion that this river must, from the accounts of the ancients, have formerly been of much greater magnitude at all seasons of the year than it appears to be now.

The excessive rains which fall in tropical regions during a certain season of the year, occasion inundations of the rivers within the torrid zone, to which such rains are chiefly confined. In the frgid zone, the season of floods is in spring, when the ice and snow melt. These floods are violent, and of short duration. Some of these rivers have two or three successive floods, corresponding to the seasons of thaw on the low grounds, on the sides of the mountains, and on their summits. The inundations of the Nile are periodical, and begin in June. It draws its waters from the tropical regions, where excessive periodical rains cause other rivers to overflow. By the middle of August, the whole valley of Egypt is covered with water.

The swelling of the Ganges, which arises partly from rains, and partly from the melting of snow, begins in April, and continues till

the middle of August, when it attains to its maximum height, which is thirty-one or thirty-two feet.

§ XXXVI.—Dimensions of Rivers.

In order to ascertain the actual dimensions of a river, it is necessary to determine its length, and depth, the area of its basin, and the amount of its annual discharge of waters. In estimating its length, we may trace its windings, by its channels, from its source to its mouth; or we may compute only its principal bends. It is this different manner of estimating the length of the river's course, and other causes, that lead to so many inconsistent statements. The following tables state the length of the rivers, allowing only for the principal bends; and it is often necessary to add from one fourth to one sixth, to give the entire length of the channel.

I. SOUTH AMERICAN RIVERS.

Rivers.	Length.		Area of Basin.
Amazon,	3,200	Miles.	2,500,000
La Plata,	2,130	"	1,250,000
Orinoco,	1,150	"	300,000
Magdalena,	820	"	
Tocantin, or Para,	1,500	"	
San Francisco,	1,275	"	
Madeira,—tributary of Amazon,	1,800	"	
Topayos, . . . do.	1,000	"	
Napo, . . . do.	800	"	
Xingu, . . . do.	1,080	"	
Negro, . . . do.	1,400	"	

I. NORTH AMERICAN RIVERS.

Rivers.	Length.		Area of Basin.
Mississippi,	2,300	Miles.	1,250,000
Missouri, to mouth of Mississippi,	3,500		
Oregon, or Columbia,	1,200	"	
St. Lawrence,	2,000	"	600,000
Mackenzie,	1,500	"	300,000
Nelson and Winnipeg,	1,000	"	250,000
Ottawas,	1,200	"	
Arkansas,	1,300	"	200,000

Rivers.	Length.		Area of Basin.
Red River,	1,150	Miles	
Ohio,	800	"	200,000
Colorado,	800	"	
Bravo Del Norte,	1,250	"	
Susquehannah,	300	"	30,000
Tennessee,	680	"	41,600
Cumberland,	400	"	18,000
Potomac,	370	"	13,000
Hudson,	300	"	
Mobile, or Alabama,	400	"	40,000
Delaware,	275	"	12,000
Illinois,	400	"	24,000
Connecticut,	310	"	
James,	370	"	10,500

III. EUROPEAN RIVERS.

Rivers.	Length.		Area of Basin.
Volga,	1,900	Miles.	640,000
Danube,	1,630	"	310,000
Dnieper,	1,050	"	200,000
Don,	860	"	205,000
Rhine,	830	"	70,000
Dwina,	700	"	125,000
Vistula,	650	"	70,000
Loire,	620	"	48,000
Elbe,	580	"	50,000
Rhone,	540	"	
Duna,	490	"	
Dniester,	480	"	
Tagus,	520	"	28,760
Meuse,	520	"	
Seine,	480	"	26,200
Oder,	460	"	43,926
Douro,	455	"	35,000
Ebro,	410	"	
Po,	380	"	27,000
Thames,	200	"	5,000
Shannon,	220	"	
Severn,	210	"	
Tiber,	210	"	

IV. AFRICAN RIVERS.

Rivers.	Length.	Area of Basin.
Nile, ...	2,750 Miles.	500,000
Niger, ...	2,200 "	450,000
Congo, or Zaire, . . .	1,400 "	
Senegal, ...	850 "	
Gambia, ...	600 "	
Orange, ...	1,050 "	
Zambese, ...	950 "	

V. ASIATIC RIVERS.

Rivers.	Length.	Area of Basin.
Yangtsekiang, or Kianku,	2,700 Miles.	600,000
Yenisei, ...	2,900 "	1,200,000
Obi, ...	2,800 "	1,300,000
Lena, ...	2,500 "	960,000
Indus, ...	1,700 "	400,000
Cambodia, ...	1,700 "	
Amour, ...	2,240 "	900,000
Ganges, ...	1,350 "	600,000
Euphrates, ...	1,360 "	230,000
Hoangho, ...	2,400 "	400,000
Jihon, or Oxus, ...	1,300 "	
Sirr, or Jaxartes, ...	1,200 "	
Ural, ...	1,050 "	
Maykiang, ...	1,700 "	
Takiang, ...	1,050 "	
Meinam, or Siam, ...	850 "	

§ XXXVII.—Lakes.

Extensive accumulations of water, surrounded on all sides by land, and having no direct communication with the ocean, or with any sea, are called lakes. Lakes are of four kinds.

The first class comprehends those which have no outlet, and which do not receive any running water. These pools are usually very small, and do not merit much attention. Of these are the Arendt, in Viéille Marche, which is formed by the sinking down of the circumjacent lands, and the Lake of Albano, near Rome, which appears to be an old crater filled with water.

The second class consists of those lakes which have an outlet, but

which do not receive any running water. Such a lake is formed by a spring, or perhaps by a multitude of springs, which, opening into a kind of reservoir, are obliged to fill that before they can find an outlet for their own waters. Those lakes may, nevertheless, be fed by little invisible streams of water, which descend from the surrounding lands or from subterraneous canals. Some great rivers have lakes of this kind for their source. These lakes are generally situated on great elevations. There is one of this kind on Mount Rotondo, in Corsica, which is 6,294 feet above the level of the sea.

The third class of lakes is very numerous, consisting of all such as receive and discharge streams of water. Each of the lakes of this class may be regarded as forming a basin, for the reception of the neighboring waters. They have, in general, one outlet, which almost always takes its name from the principal river which flows into it. But it cannot, with truth, be said that these rivers traverse the lake, as their waters mingle with those of the basin over which they are diffused. There are four or five lakes of this class in North America, which, in point of extent, resemble seas, but which, by the flow of a continual stream of fresh water through them, preserve their clearness and sweetness.

The fourth class of lakes presents phenomena more difficult to explain. We mean those lakes which receive streams of water, and often great rivers, without having any visible outlet. The most celebrated of these is the Caspian Sea, of which we have already spoken. Asia contains a great many others besides. South America contains the Lake Titicaca, which has no efflux, though it receives a large river. These lakes mostly belong to the interior of great continents; they are placed on plains which have no sensible declivity towards the sea, and which do not permit these collections of water to open for themselves a passage through which they may flow out. But it may be asked, why do these lakes which are always receiving supplies of water, but have no outlet, not overflow their banks? The reply is, that evaporation is sufficient, in all such cases, to carry off their excess of water, as has been shown to the entire satisfaction of men of science.

Subterranean lakes form a class of lakes which differ from all the preceding, and are bodies of water contained in cavities quite covered by earthy strata. It is only when such cavities are laid open by earthquakes, by the falling asunder of mountains, by the action of the weather, or by rivers, by the operations of mining, or when the roof falls in, that their situation becomes known. They are very numerous, though small in size. It is not easy to account for the existence of permanent and uniform springs, on any other supposition than that they are fed by such lakes. Some of these appear to give rise to rivers, while others are known to receive very considerable streams,

which lose themselves in the interior of the ground. Such are the numerous cavities of the Julian Alps. It is to similar reservoirs that we must attribute the periodical disappearance of certain lakes situated above ground. There are some caverns in Norway which afford a passage to rapid currents of water, as appears from the sound heard through their roofs. It is natural to suppose that many streams, finding no readier outlet, flow into subterranean cavities, are absorbed by the earth, or discharge themselves under ground into the sea. In this way may be explained the origin of those springs of fresh water, that are to be seen spouting up even in the midst of the waves of the ocean. The waters thrown up by volcanoes, the sudden and terrible inundation of mines, the number of rivers which disappear, the mountains which are suddenly engulfed in the bosom of new lakes,—all these facts leave no doubt of the existence of extensive subterranean cavities, containing large bodies of water. The digging of wells has supplied a fact still more interesting. It appears that there are many lakes, or rather sheets of water, which extend under ground to considerable distances. In digging wells near Aix, in France, and in the province of Artois, they always come to a clayey bed, which, on being pierced, throws out water in large bubbles, and forms permanent springs. There is a district in the interior of Algiers, where the inhabitants, after digging to a depth of 200 fathoms, invariably come to water, which flows up in such abundance that they call it a subterranean sea. This practice has now become common, and such wells are called *Artesian*, from Artois.

Lakes which receive much water, but have no outlet, were long believed to communicate with the ocean by subterraneous channels. The great distance of some of them from the ocean, seemed to offer an obstacle to this supposition, which might have still remained in doubt, but for the discovery of the remarkable fact that some of the principal lakes of this description have their surfaces depressed far below the surface of the ocean, as is the case with several formerly mentioned. And although the level of such lakes varies with the weather, with the abundance or scarcity of the waters discharged into them by rivers, at particular seasons of the year, they are uniformly far below the sea-level.

§ XXXVIII.—Periodical Lakes.

Periodical lakes are those which are formed by excessive rains, and which are again dried up by evaporation or infiltration. They appear scarcely worthy of attention. In the temperate zones, indeed, they are *nothing but pools; but*, between the tropics, these pools some-

times cover spaces of several hundred miles in length and breadth. Such are the famous lakes of Xarages and Paria, sometimes inscribed on maps of America, and occasionally expunged. It is probable that Africa also contains many of the same kind. If there exist in the cavities of the earth, subterraneous lakes of this kind, and if they communicate with other lakes that are visible, it is easy to imagine that the waters of these last may sometimes entirely disappear by sinking down into the basin of the former, in proportion as these dry up. This lower basin again filling itself up anew, its waters spread so as to fill the superior basin. If, in a supposable series of subterraneous cavities, the last link of the chain happen to be a mass of subterraneous water, situated at a higher level in the bosom of a mountain, the periodical returns of the waters in the visible basin may be accompanied by a motion similar to that of spouting fountains. It is by means of such hydraulic machinery, that nature keeps up the wonders of the lake Cirknitz, in Illyria, and in many others of the same description.

By comparing the observations made since 1715, upon the Caspian Sea, we are convinced that this great lake augments and diminishes from 30 to 35 feet, according to the abundance of snow and rain in the countries from which it receives its waters; but we see, at the same time, that these changes have no fixed period. The lakes which are supplied with water by the melting of the snow, may even change their level in the course of the day, according as the action of the sun has more or less effect upon the neighboring mountains. It is on this principle that the seiches, or periodical risings and fallings of the lake of Geneva, should be explained.

§ XXXIX.—Lakes which Rise and Boil.

The variations and motions of lakes which do not depend upon an augmentation of quantity, present very complicated questions. That any lakes communicate under ground with the sea, and owe their regular tides to such communication, is much to be doubted. The equilibrium of the atmosphere, deranged by electricity, or by any other cause, may occasion water to rise up, by altering the pressure which retains it at its level.

In Portugal, there is a pool near Beja, in Alentejo, which, by its loud noise, indicates a storm. Other lakes appear agitated by the disengagement of subterraneous gases, or by winds which blow in some cavern with which the lake communicates. Near Boleslau, in Bohemia, a lake of unfathomable depth sometimes in winter emits blasts of wind sufficiently strong to raise up in the air pieces of ice several quintals in weight.

Two considerable lakes, Loch Lomond, in Scotland, and Lake Wetter, in Sweden, often experience, during the serenest weather, violent agitations. These are supposed to be caused by subterraneous pent-up gases. In the Marche of Brandenburg, the pool of Vorestin often commences in fine weather to boil up in whirlpools, so as to engulph the little boats of the fishermen. Perhaps the decomposition of calcareous stones has an influence upon some of these phenomena.

§ XL.—Floating Islands.

When we consider, on one hand, how many inaccessible marshes there are, always floating in the water, covered with brush-wood and trees, and on the other hand, when we consider those beds of vegetables that are found very recently buried in turf-pits, we may form an idea of these floating islands, which some geographers represent as natural curiosities. They are simply earth of the nature of a peat, but very light, sometimes only reeds and roots of trees, interwoven together. After having been undermined by the waters, they detach themselves from the bank, and from their lightness, and spongy nature, and consistency, joined to their inconsiderable thickness, they remain suspended and floating on the surface of the waters.

The delightful Loch Lomond, in Scotland, contains some of these floating islands, which are very common in Scotland and Ireland. The marshy lakes of Comacchio present a great number. A small lake in Artois, near St. Omer, is covered with them. Among the largest are those in the lake of Gerdau, in Prussia, which furnish pasturage for one hundred head of cattle, and that of Lake Wolk, in the country of Osnabruck, covered with beautiful elms.

There are some floating islands which appear and disappear alternately. The Lake Ralang, in Smalande, a province of Sweden, is an instance of this kind. It encloses a floating island which, from 1696 to 1766, has shown itself ten times, generally in the months of September and October. It is 280 feet long, and 220 broad.

Floating islands may have an influence upon the formation of some parts of what appear to be alluvial plains. Those which Pliny and Seneca saw floating in the Lakes of Bolsena and others have become fixed. West Friesland has a subterraneous lake, which appears to have been covered with floating islands that gradually united together, and ended in forming a solid crust.

§ XLI.—Temperature, Depth, and Qualities of the Water of Lakes.

The shade of thick forests or high mountains may prevent lakes, like Loch Winnoch, in Scotland, from getting rid of the perpetual ice which covers them either in part or in whole. Other lakes, always ruffled by the winds, or stirred by the rivers they receive, and the springs which feed them, brave all the rigors of a cold climate. The most extraordinary phenomenon would be to see lakes freeze during summer, and this has been related of some in China, the cause of which has been sought for in the saline nature of the neighboring ground: but the fact appears to have been insufficiently observed or incorrectly recorded.

The depth of lakes varies infinitely, and cannot form a subject of general physical geography: we will content ourselves merely with contradicting the assertion that there are lakes without a bottom. No such lake has ever been discovered; those which appear to be such owe their character to currents, which carry along with them the lead attached to the sounding line. But there are lakes with double bottoms, according to various statements: such are said to exist in Sweden, in Jemptia, or Jemptland, and elsewhere. This fact is accounted for by supposing that a crust interwoven with roots, similar to the floating islands, may exist at the bottom of a lake, and by either rising or sinking, may make the depth vary in appearance. The depth of great lakes has seldom been ascertained with exactness.

There are also inland seas where the level of the waters changes with the seasons. For instance, the Baltic and the Black Seas swell in the spring from the abundance of water poured into them by rivers. These two seas approach nearer than other seas to the nature of lakes, which have generally a higher level than that of the ocean.

The depth of some parts of the Caspian seems to exceed 380 fathoms. In lakes, as in the ocean, the slope of the bank is continued downward for a considerable way below the water; that is, deep lakes are to be found in mountainous districts, and shallow marshy ones, in flatter countries. The depth of Loch Ness, in Scotland, is, in some places, 130 fathoms, which is four times the depth of the North Sea; and its bottom is actually 30 fathoms below the deepest part of that sea, between the latitudes of Dover and Inverness. The Lake of Geneva attains the still greater depth of 161 fathoms. Many other lakes are known to be exceedingly deep, without the amount being ascertained. Many, no doubt, are gradually becoming more shallow from being filled up with mud, &c.

The temperature of the surface of lakes depends upon the climate and season; but at the bottom of deep lakes it undergoes little or no change during the year, and approaches to that which corresponds to the maximum density of water, which is about 39.5°. In Loch Catrine, and Loch Lomond, the temperature, at all depths below 40 fathoms, is 41°; but the mean temperature of the climate is 47°. The deep lakes of Thun and Thug, in Switzerland, have a temperature of 42° at the depth of 15 fathoms. Geneva Lake, at the bottom, has a temperature of 42°; that of the Lake Sabatino, at Rome, is 44.5° at the depth of 80 fathoms. Warm springs may in some cases keep up the temperature when they occur at the bottom. Deep lakes scarcely ever freeze, except in a very cold climate; because the whole body of water must cool below 40° before congelation could commence. Accordingly, neither Loch Ness, nor its effluent river of the same name, are ever frozen over.

The qualities of the waters of lakes are various, according to the nature of the substances with which they may be mixed or contaminated. The principal distinctions in this respect are fresh, saline, and alkaline. Lakes which receive much fresh water and have a copious efflux, are almost always fresh; but those which lose much of their water by evaporation, may be slightly saline, especially if the neighboring soil abound in salt. When lakes have no outlet, they are invariably saline. To account for this, two reasons have been assigned: one is, that salt lakes having no outlet, are concentrated portions of the waters of the Deluge, retained by the hollows of the earth's surface; and that all other lakes were originally such, and saline; but that those which are traversed by fresh-water streams have had their salt washed out, and carried to the ocean.

The other opinion is, that the salt in lakes has come from springs, or been washed out from the soil of the adjacent country, by means of the rain and rivers; for such lakes are most abundant where the soil contains saline matter: and where lakes only lose water by evaporation, the vapor goes off fresh, and leaves the salt behind. The Dead Sea is one of the saltest of all lakes, and appears to have been so for upwards of 4,000 years: for in the book of Genesis it is called by way of distinction, the "Salt Sea." The waters of this lake are in a state of saturation, containing about 8 times as much salt as those of the ocean. The salt must be accumulating in beds at its bottom: for the river Jordan, which is brackish, necessarily carries in more. Masses of bitumen frequently float on the surface, and seem to rise from the bottom of the lake. Hence its Greek name Asphaltites, from *asphaltos*, bitumen. The same thing occurs in other Asiatic lakes, some of which are impregnated with borax. In the *Island of Trinidad, in* the West Indies, there is a lake which pro-

duces an enormous quantity of bitumen, fit for naval purposes. It is three miles in circumference, and the pitch is frequently so hard as to sustain men and quadrupeds.

Some lakes are both saline and alkaline, as is the case with a number of lakes in Lower Egypt. These are called Natron lakes, from their abounding in soda, which is there called trona and natron, the nitre of the sacred writings.

§ XLII.—Disappearance and Formation of Lakes.

Lakes appear to have been much more numerous at a former period than at present, and to have occupied a large proportion of the surface of the land. Traces of their existence occur everywhere. Many of them have been filled up with débris, and become level plains, traversed by a river. Some have been drained by the gradual deepening of their outlets, or both causes have operated together. Others have been drained by cracks caused by earthquakes, or by the subsiding of part of their basin. The whole kingdom of Hungary is supposed to have been originally the basin of a lake.

There are several modes in which new lakes may be formed. When a mountain falls asunder, it often happens that it stops up a neighboring river and valley, and forms a lake. But the water of a river, obstructed in this manner, will always overflow, and can scarcely fail to regain its former level, either by wearing away a cut for itself above, or by undermining the ruins beneath. Shallow, marshy lakes are often formed by the surplus waters of rivers, detained on flat ground by an accumulation of mud. Ice and snow sometimes accumulate in narrow passes between mountains, so as to obstruct and make the water stagnant, and form a temporary lake, increasing perhaps for years, till at length the pressure of the water is augmented to such a degree as to burst the icy barrier. So great a discharge of water and ice, precipitated from mountains, tears up not only alluvial substances, but frequently, portions of rocks, which are scattered over the plain below. Thus, villages and fertile fields are almost instantly converted into deep hollows and heaps of rubbish. These cavities, perhaps, continue filled with water, forming small lakes.

§ XLIII.—Properties of Various Kinds of Water.

Water is never found perfectly pure in nature, owing to its very strong and extensive power of dissolving other substances. It possesses the property of absorbing the atmospheric air, of which it generally

holds in solution $\frac{1}{30}$ of its weight. But as it absorbs oxygen more readily than hydrogen, the air it contains is richer in oxygen than common atmospheric air. Fish consume a great deal of this oxygen: hence, they perish when the water has been deprived of it. But in general, as they consume it, the water absorbs more from the atmosphere; and this process is facilitated by the movements of the water.

Rain water is the purest found in nature: but, besides atmospheric air, it contains carbonic acid, and a small portion of ammoniacal salt, even when most pure. Perfectly pure water is obtained by carefully boiling and distilling rain water.

The waters of marshes, pools, and all stagnant waters, are unwholesome, because they dissolve carbureted hydrogen, nitrogen, and hydrogen gases, arising from the decomposition of plants, insects, and fish.

The water of hills and mountains differs in its quality, according as it filters through banks of quartz or clayey rock, from which it derives no property whatever, or as it traverses ground which is marly, calcareous, gypseous, or impregnated with magnesia, salt, or bitumen. The former kinds are always wholesome: but the last kind is generally much mixed with heterogeneous substances, and is generally hard and turbid, and sometimes unwholesome. Although those waters which have clayey bottoms are wholesome, yet those which flow through hard rock are more pure and limpid, as they undergo a process of filtration in flowing through the stony soil.

The waters of lakes, being derived from springs and rivers, partake of their different qualities. There are some lakes whose waters are extremely limpid, such as Geneva, in Switzerland, and Wetter, in Sweden. In the latter, it is said, a farthing coin may be perceived at the bottom of the lake, at 120 feet depth. But the waters of lakes which are motionless, or saline, or bituminous, may be regarded as equally unwholesome with those of marshes.

The waters of rivers contain some very heterogeneous elements, which seem necessarily to counteract each other; and it is, perhaps, as much owing to this reciprocal destruction of pernicious principles, as to continual motion, that river water is so generally serviceable to the wants of man, and supports the freshness and purity of the atmosphere, wherever it flows. It often, however, forms a sediment of gravel and mud.

Well water, by remaining too long motionless, is apt to acquire the bad qualities of stagnant waters, in certain circumstances; but it is generally wholesome.

Snow and ice water have been charged with producing *goitres*, or swelled neck: but this cannot be so; for there are many localities where they are freely used, without any case of that disease being known. The only objection to such waters is their great coldness.

Mineral waters are those which are combined with certain substances of the mineral kingdom, in a quantity sufficient to impart to them both taste and color; the absence of which properties constitutes the chief characteristic of fresh water.

Acids easily combine with water, but they are as rapidly incorporated with any saline, earthy, or metallic substance; so that acidulated waters seldom contain free, unmixed acid. The Spring of Latera, however, 32 miles from Viterbo, and that of Selvena, 46 miles from Sienna, are produced as examples in which free sulphuric acid is combined with water. The Lakes of Cherchiàio, of Castel Nuova, and Monte Rotondo, also in Italy, present free boracic acid.

The acidulated ferruginous waters, or chalybeates, are the most common. There are some hundreds in France and Germany. The acid in these is combined with ferruginous ochre; and they frequently contain magnesia, Glauber salts, vegetable alkali, and hydrochlorate of soda; but the simple chalybeate are the most common. Those of Passy contain green vitriol, or sulphate of iron, and become black with astringent vegetables. Bitter waters are charged with sulphate of magnesia. Such are those of Seidlitz and Epsom. The Steppes of Siberia, to the north-east of the Caspian Sea, have a number of lakes of this kind. They almost form a chain from the Kuma and Bas Volga, reaching from thence beyond the Yenisei. Near these pools there are some which contain alkali, or carbonate of soda. In the plains of Hungary, the same abundance of bitter waters is found. Perhaps this is a property common to all the basins of the ancient Mediterranean Seas.

The formation of the acidulated waters, is one of those daily operations of nature which has been subjected to the scrutiny of science. Running waters find in the bosom of the earth acidiferous substances, the acid of which either is disengaged by their affinity for the water, or by stronger acids mingling with weaker ones, and causing fermentation. This chemical process is perpetually renewed. Lime, which contains $\frac{2}{5}$ of its weight of carbonic acid, supplies in abundance, mineral waters with this acid, which constitutes their general basis. Sulphuric acid is disengaged from pyrites, which are widely distributed over the earth. Waters impregnated with this acid will dissolve iron, lime, magnesia, and many other substances.

Mineral waters do not remain in that state in which a first chemical operation placed them; for, in their course through the earth they sometimes meet with a salt, and sometimes with an acid; and these different substances, by uniting, separating, or changing, according to their affinities, with the basis of mineral waters, communicate qualities to them which serve to vary their chemical and medical nature.

Without mentioning those sulphurous waters, or carbonic fumes which arise from several waters, it appears certain, that there are several springs impregnated with mercurial and arsenical vapors. Happily these frightful laboratories, in which nature sustains a poisonous character, are generally buried under large masses of rock; and the rarity and insolubility of arsenic render arsenical springs very uncommon.

Metallic waters are those in which minute particles of metal are suspended, and which, not being combined with the fluid, are gradually deposited. Besides the common cementatory waters, as they are termed, which yield iron and copper, some are mentioned which have formed a deposit of argentiferous lead, in a mine of Konigsberg. The auriferous rivers do not even retain the particles in suspension; they roll along grains of gold detached from some rock. These waters are not mineral in the proper sense of the word.

Salt, or muriated waters, are perhaps the most common of all; but they rarely exist in a state of perfect purity. They occur in abundance along the Carpathian and Uralian mountains, and in general in the zone comprised between the parallels of 50° and 80° north latitude. More to the north they are hardly ever found; further to the south crystallized salt abounds in certain regions, as in the great desert of Africa, but we find only a few salt springs there. It is also in the north temperate zone that salt lakes are most abundant. The central part of Asia has a vast number of them. The origin of such lakes has been already explained.

There are some waters which are capable of taking fire without being hot. Sometimes they contain hydrogen gas, disengaged from mines of iron, zinc, and tin, dissolved by the hydrochloric and sulphuric acids. Such are the fountains of Porretta Nuova, Barigazo, and others. Such is the rivulet near Bergerac, which can be set fire to with lighted straw. Sometimes these waters are mixed with pitch, or bitumen, especially with naphtha and rock oil, which in general float on the surface, and burn in the depths of the water: this is seen at Bakou, and in several places in Persia. The burning lake of Iceland appears to belong to the first class; and it is not improbable that it may have sometimes taken fire spontaneously.

Incrusting waters ought to be carefully distinguished from those possessed of a petrifying quality. These last, charged with siliceous particles extremely minute, penetrate the pores of wood and other substances, and substitute for the elements of these bodies other crystallized elements arranged in the same manner. This property shows itself stronger than anywhere else in Lough Neagh, in Ireland, and in some few springs; but most hard waters possess it in a certain degree. The Danube and the Pregel petrify, in the course of some ages, stakes which are planted in their waters.

Incrusting waters act in a more evident manner, by depositing like a crust the earthy particles with which they are loaded. Of these we have examples in the spring of Guancavelica, which, by depositing calcareous sediments, furnishes the rough stones of which the neighboring towns are built,—the beautiful alabaster formed by the baths of San Phillipe, in Tuscany,—the deposits known by the name of Sugar Plumbs of Tivoli, and the magnificent basin formed by the springs of Carlsbad. This quality of incrustation is most common in hot springs; but it is found also in several cold springs. The ordinary deposits consist of calcareous tufa or sand-stone. The Geysers of Iceland deposit a siliceous tufa.

§ XLIV.—Destroying Effects of Water.

Water is a very active agent in altering and variously modifying the surface of the earth, and its energy is increased when it carries along with it mechanical matter, such as sand, gravel, etc., and particularly, when it is aided by the gnawing influence of the atmosphere. Through these agents the whole surface of the dry land is kept, more or less, in a state of motion, by their breaking up the strata, and removing, with greater or less rapidity, the broken rocky matters, from point to point, and often into lakes and seas.

Water destroys both mechanically and chemically. It destroys mechanically, when it removes part of the soil or broken rocky matter over which it passes, or corrodes the channel in which it flows, or the reservoirs in which it is contained; it also destroys mechanically, when, on being imbibed by rocks, it increases their weight, and thus favors their rending, slipping, or overturning; and lastly, it destroys mechanically, when, by freezing in fissures, it breaks up mountain masses and rocks. It destroys chemically, when it dissolves particular mineral substances, as rock-salt, out of the rocks through which it percolates.

Running waters, in their course from the higher to the lower parts of a country, carry along with them the débris already prepared by the action of the weather on exposed rocks, and also more or less considerable portions of the strata of the basin in which they flow. The quantity of abraded matter depends in a great degree on the quantity of sand, or gravel, that the river carries along with it; for running water, when pure, acts but slowly on compact strata, and displays its scooping or excavating power, only when carrying along with it sand, gravel, and such other matters, which communicate to it a mechanical destroying action. As the velocity of the river diminishes, its carrying power diminishes; and, frequently, long before it has reached the water into which it discharges itself, it carries only

fine mud, leaving the gravel and larger solid masses in the higher parts of its course. The transporting power of water is much greater than many are aware of. It is strikingly shown by the enormous quantities of rubbish, and great blocks of stone, which are swept away by rivulets during floods. This transporting power is materially assisted by the weight of the rocks, when immersed in the water, being diminished from one third to one half. The transporting of heavy stones by water, in situations where ice occurs, is assisted by the ice, which adheres to them, and which greatly diminishes the specific gravity of the mass.

The influence of lakes is visible in the beaches on the margin of many of them, formed of the broken fragments of the neighboring rocks. It is still more palpable in the great changes in the neighboring country, occasioned by the bursting of lakes.

The waters of the ocean exercise a powerful destroying effect on coasts. If the coasts are bold and rugged, they are violently assaulted by the waves of the ocean; the crags and cliffs tumble down, after being split in frightful and irregular succession. The perforated rock of Doreholm, on the west coast of Shetland; the perforated rocks described by Captain Cook, near New Zealand; the Stalks, Holms, and Skerries, on the coasts of Shetland, Norway, and Scotland, are effects of the destroying power of the waves of the ocean, conjoined with the gnawing action of the weather.

On those rocky coasts where the strata are of unequal hardness, the softer portions, and also part of the surrounding harder mass, are removed by the action of the waves, and thus sea caves are formed. The waters of the ocean also frequently cause dreadful ravages in the low countries exposed to their fury. Holland furnishes many striking examples of its devastating power. In the year 1225, the waters of the ocean, agitated by a violent tempest, inundated the country. The Rhine, swollen at the same time by extraordinary floods, and retained at a great height, partly by the waters of the ocean, and partly by the wind blowing in a contrary direction to its course, spread over the neighboring country; but the tempest having suddenly subsided, the highly elevated waters retired, and with such force and velocity, that they carried with them considerable portions of the soil, and left in its place the sea called the Zuyder Zee. In the year 1421, a great inundation submerged the southern part of the Province of Holland, drowned 60,000 persons, and then retired, leaving the Bies Boos.

The agitations of the sea sometimes reach to a depth of upwards of 200 feet; and the power of the ocean, far below its surface, is so great as to break rocks in pieces, and throw them upon the coasts in masses of various sizes and forms. Some drift stones of large dimensions, measuring upwards of 30 cubic feet, or more than 2 tons

weight, have been often thrown from deep water upon the Bell Rock, on the eastern coast of Scotland. These large bowlder stones are so familiar to the keepers of the light-house erected on the rock, as to be termed by them, travellers.

The currents that traverse the ocean, like rivers on dry land, probably scoop out beds for themselves, and carry away, often to distant places, great quantities of abraded matter. The Gulf Stream, and other branches of the great equinoctial current, may act powerfully in this way; and the same may be the case with the currents in our own seas, and those that enter inland seas, and wind round them, as the Baltic and Mediterranean.

Water, by its own weight, contributes very much to the degradation of the surface of the globe. Sometimes great masses of rock, especially those of a soft and porous nature, imbibe much water, by which their weight is increased, and thus occasions breaking and slipping of masses, often of enormous magnitude. Clay beds sometimes become soft by the filtering through of rain or snow water, from the overlying rocks. When these rocks thus lose their support, the clay and superimposed rocks are inclined at a considerable angle; the rocks, in great masses, separate and slide down into the lower part of the country. The fall of the Rossberg, in Switzerland, in September, 1802, may be mentioned as an example of this phenomenon. This mountain is 5,193 feet high, and lies opposite to the Rigiberg, which rises 6,182 feet above the sea. The Rossberg is composed of soft greenstone with beds of clay, and all inclined at an angle of 45° to 50°. It is said that the clay in some of the beds was much softened by the percolating water, and the thick superincumbent beds of greenstone, in this way losing their support, were separated from the inclined soft surface below, and slid into the valley underneath them. This landslip of débris and mud overwhelmed several villages, and destroyed from 800 to 900 persons. In 1714, the west side of the Diablerets, in Switzerland, separated, and in its course downwards, covered the neighboring country with its ruins, for two miles in length and breadth; and the immense blocks of stones and heaps of rubbish interrupted the course of the rivers; and lakes were thus formed. In 1618, the once considerable town of Pleurs, in the Grisons, with the neighboring village of Ichelano, were overwhelmed by a vast mass of rock, which had imbibed much water, and separated itself from the south side of the Mountain of Corto.

In those regions of the earth where the freezing and thawing of water take place, the expansive and destroying action of freezing water is often displayed on a great scale. In the history of northern countries, we read many accounts of the noises and rendings of rocks, occasioned by the expansion of water during its freezing in their fissures. Terrible disasters sometimes take place in Alpine countries,

by the bursting and fall of great masses of rock, split in pieces by the freezing of the water in its clefts.

Water in the form of ice causes considerable changes on the surface of the earth. Thus, when floated along in great masses by rivers, it breaks up their banks, and thus affords them an opportunity of devastating the lower country; and the masses are often so great, that enormous heaps of rocks are thereby torn off, and carried to a distance. When sea ice is drifted against the cliffs and precipices along the coast, the breaking and destruction it occasions almost surpass belief.

To break, destroy, and move large masses of rock, one of the most powerful engines employed by nature, is glaciers. These masses of congealed water and snow, in their course downward, push before them enormous quantities of earth and broken rocky matter, which form those great mounds, named moraines, of which we have formerly spoken.

Water generally enters into the fissures of rocks in a rather pure state; but it issues forth again more or less impregnated with mineral matters of various kinds, taken up from the substances through which it has passed. The most abundant substance brought out in this way, from the interior of the crust of the earth, is lime, which is deposited from these calcareous waters in the form of tufa, which is a porous limestone, with an earthy matter mixed in it. Many of the excavations in limestone are partly owing to this destroying effect of water. Spring water, in passing through beds of gypsum and rock-salt, dissolves a portion of these minerals, and in this way occasions considerable changes in the interior, and even on the surface of the earth, by the yielding of the rocks over the hollows formed by the removal of the salt and gypsum.

§ XLV.—Forming Effects of Water.

Springs bring from the interior of the earth, muddy matter of various descriptions: and in the course of time, hillocks, and even hills of considerable magnitude, are thus formed.

When lakes are filled up, or are emptied, we find the space formerly occupied by them covered, to a greater or less depth, with the alluvial matter brought into them by the streams which flow into them. When lakes burst their barriers at different times, they leave on their sides a series of natural terraces, or platforms, of which we have a splendid example in Glen Roy. In this valley these terraces are known by the name of *Parallel Roads* of Glen Roy; because some supposed that they were not natural arrangements, but roads formed by the ancient inhabitants.

When rivers are in a state of flood they often overflow their banl and cover the neighboring country with their waters. Thus t Ganges, near its mouth, in the rainy season, overflows the count to a breadth of one hundred miles, and a depth of nearly twel feet. And the Indus, during the period of inundation, extends thir or forty miles from its banks. This flood carries with it muddy a other matters, and deposits them upon the land. It is said, that t annual floods of the Nile have raised the surface of Upper Egy about six feet, four inches, since the commencement of the Christi era, or four inches in a century. In other countries, extensive d posits, extending along the sides of rivers, are formed by the ov flowing of their waters. Where rivers enter lakes and the sea, th form triangular pieces of land, called *deltas*, from the resemblance their form to the Greek letter D, which they called *delta*.

These deltas are more strongly marked in lakes than in inland se and in these seas more than in the ocean, where the depositions a much interrupted by currents. The most famous delta mentioned history, is that of the Nile, which has been considerably enlarg since the time of Herodotus, but not to the extent stated by ma writers. At no great distance from the shore of the Delta, the dep of the Mediterranean is about 72 feet; and further out, the sea sudden deepens to 2,000 feet, which may be considered to be the origir depth of this part of the Mediterranean. The deltas of other rive exhibit phenomena similar to those of the Delta of Egypt, and their considerable extent, and annual increase, furnish ample proof the forming power of rivers. That of the Niger is 300 miles lor and 170 miles broad. The delta of the Ganges runs 200 miles alo the coast, and 220 miles up from its present mouth.

The alluvial matter brought down by rivers, not only forms gre tracts of land at their mouths, but also, through the agency of cu rents, assisted by the waves of the ocean, gives rise to extensi tracts of low and flat land, which extends along the coasts. With the last 2,000 years, a tract 100 miles long by 18 broad, has be formed along the Italian coast, round the mouth of the Po.

When the sea coast is low, and the bottom light sand, the wav push this towards the shore, where, at every reflux of the tide, becomes partially dried, and the winds, which often blow from t sea, drift up some portions of it upon the beach. By this formi action of the ocean, sandy flats and downs, or ranges of sand hills, a formed along the coasts. When this sand is moved about by t wind, it forms what is called the sand flood. Westward from t mouth of the River Findhorn, in Scotland, a district consisting upwards of ten square miles of land, which, owing to its fertilit was once named the granary of Moray, has been depopulated, a rendered utterly unproductive by the sand flood, which has convert

it into a barren waste. The sand hills of Barry, at the mouth of the Tay, composed of blown sand, are from 200 to 300 feet high.

These barriers sometimes give way, when the tract is again, for a time, covered with the sea; a new barrier again rises, and the sea is again excluded. These operations, on a great scale, would afford alternations of productions of the land and the sea. The sands of the African deserts may be sea sands, or land sands, or both together.

The bed of the German Ocean supports many of those sandy accumulations called sand banks, or simply banks. One of these, called the Dogger Bank, extends north and south for upards of 350 miles. Its average height is estimated at about 78 feet. Various shoals in this sea are laid down in charts. Such banks are estimated to cover one fifth of the whole area of the North Sea, and they are all supposed to owe their origin to the action of currents and tides. There can be little doubt, also, that the Newfoundland Banks have been produced by the deposits of the Gulf Stream.

Springs, in many cases, after dissolving calcareous matter abraded from limestone rocks, allow the limestone to crystallize, in consequence of the escape of the carbonic acid, by means of which they held it in solution, and in this way form depositions of calcareous sinter, or alabaster, on the roofs, sides, and floors of caves; or fill up fissures in rocks, and form veins; or if they flow over the surface of rocks, they form beds of calcareous sinter or tufa. These beds sometimes extend very far, with a thickness of 200 or 300 feet.

The water of such springs, when collected into hollows, so as to form lakes, often deposits vast quantities of calcareous tufa and sinter;* and hence, such lakes, when emptied, present extensive calcareous deposits. The travertine employed at Rome for building, is a lake or spring deposit of sinter and tufa. The town of Guancavelica, in South America, is built of a compact calcareous tufa, from the calcareous springs in the neighborhood. In the mountain limestone districts in England, and also in the Lias districts, both in England and Scotland, the roofs, walls, and floors of the caves are often elegantly ornamented by numerous varieties of calcareous sinter, which form complete columns of various fantastic shapes.

In the marshes of the great plain of the vast circular valley of Hungary, there is a constant deposition of horizontal layers of calcareous tufa and sinter, which are so hard as to be fit for building; and all the houses of Czelea are constructed of these minerals.

The pea-stone, a beautiful calcareous carbonate, is formed abundantly from the waters of calcareous hot springs, such as those of

* *If the matter deposited is light* and porous, it is termed *tufa* or *tuff*; if it *is arranged in solid, concentric* layers, it forms *sinter*.

Carlsbad. As these calcareous springs often flow into rivers, a vast quantity of carbonate of lime may thus reach the ocean, where it will be deposited in the various forms of sinter, tufa, and common limestone. The Geysers of Iceland, and those of St. Michael's, in the Azores, deposit on the dry land vast quantities of siliceous sinter, a mineral which differs little from opal. The deposit around the Geysers is one mile in diameter, and 12 miles thick. In the Azores, the deposit is sometimes 30 feet high. Such springs also pour their waters into the ocean, and even rise from the bottom of the sea, sometimes with such force as to jet above the surface. Their silica is deposited on the submarine land in various forms and states, according to circumstances.

Bog iron ore is often found in such situations as to show that it has been deposited from the waters of lakes; and in some countries it is collected from the sides and bottoms of lakes at regular intervals, thus showing that it is still forming in such situations. It is also well known that in salt lakes extensive deposits of salt occur.

Collections of entire and broken sea shells and corals are sometimes found agglutinated by calcareous, clayey, or ferruginous matters, forming banks or beds of considerable extent. Beds of this kind, particularly those formed of shells, are met with in many parts of England.

In the West Indies, a solid conglomerate of shells and corals lines a considerable extent of coast on several of the islands. The celebrated human skeleton from the Island of Guadaloupe, now in the British Museum, was found imbedded in a rock of this description.

DIVISION SECOND.

GEOGNOSY, OR DESCRIPTION OF THE GENERAL STRUCTURE, CONFIGURATION, AND NATURAL DIVISIONS OF THE LAND.

§ I.—General Distribution and Aspect of the Land.

The land is arranged into masses of various magnitudes and forms. It is not equally distributed, for a much larger portion of it occurs to the north than to the south of the equator. About the middle of the last century, it was asserted that a great continent must exist towards the South Pole, in order to counterbalance the mass of land in the northern hemisphere; and accordingly Lieut. Wilkes, of the United States Exploring Expedition, recently discovered what is considered an antarctic continent; but its extent is unknown, and will probably long continue so.

In February, 1819, land was discovered by William Smith, commander of an English brig, when the ship was in latitude 62° 40′ south, longitude 60° west. He traced the coast for 250 miles. This land is probably part of the continent. Although a southern continent has been discovered, the theories which led former geographers to expect it are demonstrably futile. There is no necessity whatever for land to produce an equilibrium, as the water would, under the influence of gravitation, always balance itself, however the dry land happened to be distributed. The particular mode of this distribution could only affect the form of the globe, and that only very slightly.

Two grand divisions of the land are named Worlds, viz.: the *Old World* and the *New World*. The Old World, otherwise called the *Eastern Continent*, extends from south-west to north-east, and comprehends the three sub-continents of *Europe*, *Asia*, and *Africa*. The New World, or *Western Continent*, extends from north to south, and comprehends the sub-continents of *North* and *South America*.

The general direction of the land in the two Worlds, is different.

In the Old, it is almost parallel with the equator: while in the New, it is perpendicular to the equator. The longest straight line that can be drawn in the Old World, begins on the western coast of Africa, from about Cape Verd, and extends to Bhering's Strait, on the north-east coast of Asia. This line is about 11,000 miles in length. A similar line, traced along the New World, from the Strait of Magellan to the northern shores of North America, measures 9,000 miles. The New World runs much further north than the old, and its frigid parts are comparatively much more extensive, while its torrid regions are much less. The difference in the climates of the two Worlds, seems to depend upon this fact.

The peculiarities of the isthmuses that divide each continent into two very unequal parts are quite striking, that of Suez being composed entirely of sand, while that of Panama is formed by rocks of granite and porphyry. The Old and New Worlds resemble each other in several respects. Thus, seas and bays are distributed all over the coasts of Europe and Asia, while Africa is not penetrated by a single one; in the New, there are innumerable bays and gulfs on the eastern side, while on the west we find only the Gulf of California. Both Worlds are divided into two parts, joined by an isthmus; both have an archipelago on the eastern side, and their peninsulas all taper to the south.

Besides the Old and New Worlds above described, there occur, dispersed through the ocean, numerous smaller masses of land, forming islands of various magnitudes and forms. Those islands situated near the continents, are considered as belonging to them. Thus, the British Isles belong to Europe, those of Japan to Asia, the West India Islands to America, and Madagascar to Africa. But, besides these, there are other islands or groups of islands, situated at a distance from continents, and which cannot be referred to any of the preceding divisions. These are all included under one grand division, and arranged into the three sub-divisions mentioned in our account of the oceans.

The surface of the land presents great variety in aspect, forming mountains, hills, valleys, and plains. The most general of these features, are what the geographers term *highland* and *lowland*. Highlands are lofty, uneven, and widely-extended masses of land; thus the mountainous tract of country, extending from the Naze of Norway to the North Cape, is a highland. Lowlands are widely-extended, low, and flat countries; thus the northern part of France, the Netherlands, Holland, part of Germany and Silesia, Poland and European Russia, form what may be called the great European lowlands.

In a highland, the central parts are generally the most rugged and lofty, while the exterior districts, those which border on the lowland,

are lower and less rugged. The central part is named *Alpine;* the lower, and the exterior part, *hilly.* The Alpine part of a highland is composed of a central and lofty chain, named the *Central*, or *High Mountain Chain*, towards which there tend a greater or less number of lateral or principal; and from these, again, diverge *subordinate* chains. The High Mountain Chain forms the *water-shed* of the district; and the hollows that traverse the upper part of this chain, are called *passes.* On passing from one side to another of the Alpine land, we do not always travel through a pass, but sometimes cross a comparatively flat tract of country, many leagues in extent; such as these are named *table-lands.* In crossing from Norway to Sweden, we pass, in some parts, across a table-land; and also in travelling from Vera Cruz to Acapulco, by Mexico. The inclined planes on which the lateral or principal and subordinate chains are distributed, are named the *acclivities* of the highland. The hollows that separate these chains from each other, are called *valleys.* Those valleys bounded by principal chains of mountains, are called *principal* valleys; while those that lie between subordinate chains, are called *subordinate* valleys. The hilly or lower part of the highlands, is composed of comparatively low and less rugged chains, called *chains of hills*, which are irregularly grouped, being entirely without a high mountain chain. The valleys in this hilly land are shorter, less steep, and not so rugged, as in the Alpine or more central part of the highland.

Lowland is formed entirely of extensive plains, little elevated above the level of the sea, in which we occasionally observe gentle risings and undulations of the surface, that often extend to a considerable distance, and sometimes form the limits between neighboring rivers. Now and then, conical and table-shaped hills rise up singly and suddenly, as is the case with volcanic and igneous hills. The plains of lowland are characterized by the presence of particular hollows or concavities, which are named *river courses* or *river valleys*, because in these rivers flow. In such hollows, we distinguish the *bed* or *channel* of the river, and the holm or *bottom* land. We also frequently distinguish the *high* and *low* banks of the river, and the *ravines* or small valleys, bounded by the high banks. There is still another kind of hollow, met with in the lowland; it is that in which shallow or inconstant lakes are contained.

§ II.—Coasts and Caves.

The margin of the land, where it meets the waters of the ocean, is called by the general name of *coast.* It varies in its aspect. Sometimes it is low and shelving, and then the neighboring sea is

shallow to a considerable distance; at other times, it is steep, lofty, and rugged, and then the sea is deep. In many parts, the coast is low and sandy, and the sand is occasionally blown into hills, of which we have spoken above.

Some shores are broken and steep. This happens when a mass of rock extends, either beneath or above the surface of the soil, quite to the water, as in Gallicia, in Bretagne, in Norway, and in Scotland. Of these some are abrupt and broken, consisting of various masses of rock united at their bases, either above or beneath the surface of the water. These rocks often form clusters of islands, which surround the coasts. Such are the "garden of the king," and "garden of the queen," in Cuba;—the Archipelago of Mergui, in India;—the coasts of New South Wales,—and the Skiergord of Norway and Sweden. This class owes its peculiarities to the presence of either primary rocks or of coral reefs. Some shores again are equally steep above and below the surface of the water, leaving the sea itself quite free; these are, strictly speaking, the "steep coasts." Such frequently are those of the Mediterranean and Black Sea. Those of Dalmatia, and some parts of the Grecian Archipelago, more properly belong to the former division.

On the side of the Pacific Ocean, the American coast is uniformly steep from Cape Horn to Bhering's Straits, forming the longest continuation of steep shores upon the globe. Mariners call a coast *bold* or *bluff*, when it meets the ocean with a rapid declivity, and *clear*, when it is not bristled with rocks.

Low coasts are formed by land of a softer quality, approaching the water by a gentle and gradual slope. These may be classed into coasts formed by hills, and flat coasts formed by sands and substances which the sea has deposited. These appear under the form of sandy or marshy plains, and extend a long way into the sea, leaving the water more or less shallow. They are, however, of various kinds, sometimes consisting of the sides of low hills round which the sea has collected masses of sand, which are either fixed or shifting, and sometimes of a sort of downs formed by the sea, together with soil deposited by large rivers, as in Holland, in Egypt, and at the mouth of the Mississippi. A collection of slimy matter is also sometimes formed by the ocean, as in the flat and flooded lands, on the shores of French Guiana. The low coasts are sometimes exposed without any natural rampart, to all the fury of the waves, and then it is hard to determine whether they constitute a part of the land or of the sea. Others are secured by a chain of downs that are fixed and mingled with rocks, like those of North Jutland. It was only by a skilful and persevering imitation of these natural barriers, that the Dutch recovered the soil of their country from the empire of the ocean.

There are cavities of greater or less extent, which are either open to the light of day, in which case they are named *external* or *open* caves, or they are more or less concealed in the interior of the rocks in which they are contained, forming what are named *internal* caves. Both kinds are found most frequently in limestone rocks.

§ III.—Table-lands, or Plateaus.

We must distinguish mountains from table-lands, or *plateaus*, which consist of great masses of elevated land, commonly forming the centre of continents or of islands, but the sides of which are long and extended, and with but little apparent declivity. A plateau may have upon its elevated surface, mountains, plains, and valleys. They are generally rather level; but some of them are sufficiently inclined to allow the waters which accumulate upon them, to flow down. There are others which preserve the same level throughout a great extent, and where the rivers do not find any outlet. Some plateaus of the latter sort are met with in Europe, but they are all of small dimensions. The larger plateaus are found in Tartary, Persia, Central Africa, and above all, South America, where, in the vicinity of the Andes, the *pampas* form one of the most striking and beautiful features of the country.

The declivities of table-lands present to the inhabitants of the low countries at their base, the appearance of a long chain of mountains. The whole of Central Africa is supposed to be a vast table-land, descending by successive terraces, towards the coast, on all sides. The interior of Asia is composed of a succession of these lofty plains, of which we shall mention the most remarkable. The *Persian* table-land comprises nearly all the country south of the Caspian and Black Seas, from Asia Minor to the Indus, including Armenia, Georgia, Curdistan, Persia, and Afghanistan. This region is from 2,500 to 6,000 feet above the sea, with an area of 1,700,000 square miles. The great table-land of Thibet is from 4,000 to 17,000 feet high, with an area of 7,000,000 square miles.

The central part of Spain is a lofty table-land of about 2,200 feet in height, with an area of 90,000 square miles. Between the Alps and the Jura is the Swiss table-land, about 3,500 feet in height.

Of American table-lands, one of the most remarkable is the Mexican. On the eastern and western coasts are low countries, from which, on journeying into the interior, we immediately begin to ascend, climbing, to all appearance, a succession of lofty mountains. But the whole interior is, in fact, thus raised into the air from 4,000 to 8,000 feet. This conformation of the country has most important moral and physical results; for, while it gives the table-land, on

which the population is chiefly concentrated, a mild, temperate, healthy climate, unknown in the burning and deadly tracts of low country, into which a day's journey may carry the traveller, it also shuts out the former from an easy communication with the sea, and thus deprives it of a ready access to a market for its agricultural productions. Carriages pass without difficulty on the summit of the table-land for hundreds of miles, from Mexico to Santa Fé, but can descend to the eastern and western coasts only at a few points, owing to the steepness of the descent. This plateau has an area of about 800,000 square miles. A large part of New Grenada and Ecuador is situated at an elevation of from 5,000 to 9,000 feet, and contains populous cities, (such as Quito and Bogota,) 8,000 or 10,000 feet above the level of the sea.

Another of these table-lands includes an extensive tract in Peru, Bolivia, and the States of La Plata, stretching from 6° to 26° south latitude, and raised above the sea to the height of from 4,000 to 10,000, and even 12,000 feet. These great plateaus were each the centre of a native American civilization, at the time of the discovery of the continent.

§ IV.—Aspects of Mountains and Peaks.

Mountains, in their exterior forms, present some varieties which strike even the most inattentive observer, and which, at first sight, may lead us to presume that there is some difference in their internal composition. The highest mountains most frequently present a surface of naked rock, but the nature of the rocks produces varieties in their sections and outlines: here they shoot up into the form of enormous crystals, with sharp angles, heaped up and supported by each other: in another place, vast and elevated masses are crowned with circular summits, which rise into the air with less boldness. Sometimes there appears an immense steep and abrupt surface, which lays open to view the interior structure of the mass.

Next in order to these broken, arid, and steep summits, we see mountains, the forms of which bear a character of tranquillity,—an indication of their slow and successive formation. These mountains, which are formed by layers variously inclined, generally exhibit an infinite variety of forms, in consequence of the changes to which, from numberless causes, they have been subjected. In one place a vast amphitheatre is seen rising in majestic and regular gradation; in another, there is a large mass cut perpendicularly, and presenting the form of an altar, like the Table Mountain at the Cape of Good Hope. Some mountains have the appearance of the head of a dragon, a tiger, or a bear. In other places you see a labyrinth of rocks rising

like pillars, or in one single mass, in the form of a large nine-pin, as Mount Aiguille, in the province of Dauphiné; and near Envionne, in the Valais, are seen some which recall the figure of the old French frizzled wigs. But the most common appearances are those formed by layers of stones, in an undulated, or furrowed shape.

After these mountains of the second rank, we find hills, more or less lofty, which, on all sides, present to the eye but little elevation, and a gentle declivity. These hills, furrowed by streams, often gradually slope away, and at last lose themselves in the plains. Sometimes their sides are so rugged and precipitous, as to produce on the mind almost all the picturesque effect of high mountains.

The peaks, or highest parts of mountains, formed by volcanic agency, differ very much from the usual forms. Their conical, or pyramidal masses, are distinguished by their regularity, even when they have been broken off, or truncated by some accidental cause. Their towering summits seem to menace the neighboring country.

Basaltic mountains, also, present an appearance not less striking, when they are not covered or concealed by other soil. Their sides display to the view close ranges of immense pillars, or causeways, which seem to be the production of giants.

Some mountains present the appearance of having been bored through. The Pierre Pertuise, in Mount Jura, and Pausillippo, near Naples, are instances of this kind. The Torghat, in Norway, is pierced by an opening 150 feet high, and 3,000 long. At certain seasons of the year, the sun can be seen darting its rays from one extremity of this vault to the other. In New Zealand is a rocky arch, through which the waves of the sea pass at high water. These phenomena differ from caverns, only from the circumstance of having a passage entirely through.

§ V.—Mountain Chains.

Some mountains are completely isolated, particularly those of a volcanic origin, or of a calcareous nature. The Rock of Gibraltar, and the fortress of Gwalior, in Hindostan, are of this description. Mountains, however, are seen most frequently in groups. Sometimes chains branch out from a common centre, in angular directions. Sometimes the centre mass itself is a lofty chain, whence, at different periods, secondary chains have apparently been formed. The Alps may be placed in this class. Sometimes we see irregular groups of several chains, among which none can be distinguished from the rest. Such are the collections of mountains in Asia Minor, and in Persia. But the most remarkable sort, are the long, connected chains, which, like the Cordilléras of the Andes, in South America, continue for

hundreds and thousands of miles, nearly in one constant direction, having on both sides, regular ranges of inferior mountains, but sending off few secondary chains. These great chains evidently bear the stamp of high antiquity.

In general, all the mountainous chains on the same continent seem to have a mutual connection, more or less apparent. They form a sort of frame-work to the land, and appear to have determined, to some extent, the form it was to assume. There are many chains which have very little, or no affinity to each other. Such are the mountains of Scandinavia and of Scotland; mountains as independent as the character of the natives who inhabit them.

§ VI.—Declivities of Mountains.

Mountains, whether insulated or in groups, exhibit, on both sides, declivities which are either gentle and long, or rapid and broken. Most principal mountains have one of their sides very steep, and the other a gradual slope. The Alps, for instance, are much more rapid and steep in their descent on the Italian side than on the side of Switzerland. On the contrary, the Daufrines, or Scandinavian Alps, have a much steeper declivity on the west and north-west, than towards the south-east. The Pyrenees are steeper towards the south than on the north. The mountains of the Asturias are the reverse. But those of the Sierra-Morena, and particularly the Alpujarras, in Grenada, seem to be steepest, and most abrupt towards the south. Mount Atlas and Mount Lebanon border the Mediterranean with bold and craggy declivities. The latter is far from steep near the Euphrates. Mount Taurus exhibits two different declivities: in Caramania and Natolia, the descent is very abrupt towards the south, and there are a number of plateaus towards the north; in Armenia, the declivity on the north side is very rapid. The Ghauts of India have precipitous hills towards the west, and long, gentle slopes towards the east. In general, this inequality in declivities takes place only because the chains of mountains, when most distinct, are in a great measure nothing but the abrupt borders of long upland plains, or plateaus, obliquely inclined, of which the surface of the globe appears to be composed. We must distinguish the mountains which descend by degrees, from those which decline by successive banks. The latter may have been caused by the action of water, in the manner pointed out in Division First.

§ VII.—Uses of Mountains.

In the benevolent purposes of Providence, these great elevations of the earth's surface are made subservient to the well-being of the animal creation, and to the health and happiness of man. Rising into regions of perpetual ice and snow, they serve, in hot climates, to cool the burning air, and to fan with delicious breezes the heated breath of exhausted creation, and ward off pestilence, by purifying the atmosphere, and exciting fresh sources of vitality in the panting and languid system. They are the reservoirs of rivers, supplying the failing or exhausted streams in the low countries, during the summer and dry seasons, with copious torrents from the melting snows. They are storehouses of the richest minerals, and thus may be considered as mines of wealth. They increase the surface of the earth, and give richness and diversity to its vegetable productions. They frequently afford shelter from the piercing blasts, and by reflecting the sun's rays, they afford a genial warmth. By attracting the driving clouds, they cause the land to receive an increased amount of the "dews of heaven."

§ VIII.—Valleys.

Valleys are formed by the separation of chains of mountains, or of hills. Those which are found between high mountains are commonly narrow and long, as if they had originally been only fissures dividing their respective chains, or for the passage of extensive torrents. The angles of their direction sometimes exhibit a singular symmetry. "We see in the Pyrenees," says M. Raymond, "some valleys, whose salient and re-entrant angles so perfectly correspond, that if the force which separate them were to act in an opposite direction and bring their sides together again, they would unite so exactly, that even the fissure would not be perceived." This fact has been observed in the Alps, for the first time, by Bourquet. There are some valleys situated on a high level, totally different. We see some, which have a great extent in length, without being cut into any angles whatever, forming a sort of elevated plain. Such as these generally lie on the side of the principal chains. There are others, which are large and swelling; they appear to have been basins of some ancient lake which had become dry, from the breaking down of the bank or dam formed by the surrounding mountains.

There are also some elevated valleys, containing rivers and lakes, which have no outlet. There is a remarkable example of this in the large valley which contains the Lake of Titicaca, in Peru. Central

Asia abounds in such valleys. Several, nearly of the same sort, are to be found in other countries. High valleys present some remarkable circumstances as to their form. Some have declivities equal on all sides; others slope only on one side, and to a great extent, while the opposite side is steep, rough, and abrupt. Most of these high valleys have their surface upon a level with the summits of the secondary mountains in the neighborhood. In a few instances, these valleys have been observed to enlarge themselves at different and successive periods, but gradually to become identified with the plains. They have been, for some ages, completely barred and confined by some projecting angle of the chain of mountain which girds them in. Some valleys, lying between opposite mountainous chains, are of great extent, comprising whole provinces or countries. Such are the great valleys of the Ganges, in Asia, and of the Mississippi, in North America. Some are situated far above the level of the ocean, though sunk deep below that of the adjoining country. Such are the Chota, near Quito, which is 5,000 feet deep, and that of Rio Cataca, in Peru, which is 4,000 feet. Bootan, and Nepaul, are deep valleys of Asia. Those of the Po, of Savoy, of the Tyrol, in Europe, are instances of the same kind, though of less extent.

§ IX.—Plains.

By *plains* we understand extensive tracts of lowlands whose surface is, in the main, broken slightly, or level, or covered with gently swelling and subsiding eminences, or by inconsiderable and almost imperceptible depressions. They are found of every stage of fertility, from the inexhaustible fecundity of the Egyptian Delta to the irreclaimable sterility of the sandy deserts.

America contains vast plains, one of which extends from the shores of the Arctic Ocean to those of the Gulf of Mexico, and from the Rocky Mountains to the Alleghanies. This plain embraces the valley of the Mississippi, the St. Lawrence, the Nelson, the Churchill, and most of those of the Missouri, the Mackenzie, and the Coppermine, including an area of 3,240,000 square miles.

Another great plain comprises the central part of South America, extending over an area of 3,000,000 square miles, including more than one half of Brazil, the southern part of New Grenada, the eastern part of Ecuador and Peru, and the northern part of Bolivia. The moist and warm climate of this plain, clothes it with a luxuriant and gorgeous vegetation, nowhere equalled. The plain of the La Plata, extending from the Mountains of Brazil, to the Strait of Magellan, comprehends the whole of the southern part of South America, east of the Andes, with an area of 1,620,000 square miles.

The plain of the Orinoco, termed the *llanos*, including the region extending from the Caqueta to the mouths of the Orinoco, has an area of 350,000 square miles. These two are distinguished from the great plain of the Amazons, by the absence of trees, and the wide, grassy tracts that cover their surface.

The most extensive plain on the surface of the globe, is the vast tract stretching from the shores of the North Sea to the Pacific Ocean, and broken only by the Ural Mountains. It has an average breadth of 1,400 miles, and a length of 6,000, comprehending an area of 6,500,000 square miles. It comprises extensive heaths, sandy deserts, and steppes or open pastures, and has few considerable forests.

§ X.—Deserts.

Deserts are tracts of greater or less extent, utterly sterile, and incapable of supporting vegetable or animal life. These frightful solitudes, destitute of water or of verdure, present plains of sand, or shingle, interspersed with not less barren and arid heights, and exhibiting no indications of animated beings. In some, parched by a scorching sun, burning winds, charged with poisonous exhalations, and columns of moving sands, add to the horrors of the scene. But even these desert regions, are interspersed here and there, with little fertile tracts, rising like green islands out of the sandy ocean, well watered and well wooded, and affording shade and refreshment to the exhausted traveller. These spots are called *oases* or *waddies*.

The most extensive of these desert tracts, is the great sandy zone which stretches from the Atlantic Ocean across Africa, and Central Asia, nearly to the Pacific, or to 120° E. long. It includes nearly one fourth of the two continents through which it passes, covering an area of 6,500,000 square miles. Sahara, or the Great Desert of Africa, Arabia, and the plateaus of Persia and Thibet, present the most continued surface of sand.

America is characterized by the general absence of deserts; and it has been estimated that, although its surface is only half of that of the old world in extent, it contains at least an equal quantity of productive soil. The principal American deserts are those of Altacamá, a belt of sand extending from the northern part of Peru, with many interruptions, to Copiapo in Chili, a distance of 1,700 miles, with a width of from 10 to 50 miles; the desert of Pernambuco, which is also an arid waste of sand; and the great desert west of the Mississippi, which is about 1,400 miles long, and 400 broad, although this range exhibits some productive valleys.

§ XI.—Productive, Treeless Plains.

The surface of the earth contains several extensive tracts, which, although possessing a productive soil, are yet, in their natural state, entirely destitute of trees, and in general spread out into wide, unbroken plains. Such are the extensive open pastures of the great plain of Northern Europe and Asia, called *steppes*, the *karroos* of Southern Africa, the *prairies* of North America, the *llanos*, and *pampas*, of South America, and the *heaths* of Europe.

While the whole Atlantic slope of North America, south of the St. Lawrence, and the region west of the Rocky Mountains, were naturally covered with a dense forest, the great plain before described formed what Darby calls the *grassy* or *prairie* section, consisting chiefly of unwooded but fertile plains covered with a rich herbage, affording immense natural pastures, though occasionally degenerating into bare and arid wastes, as in the tract mentioned in the preceding section.

In Venezuela, the wide plains called *llanos* are, for half the year, covered with a luxuriant verdure, but, during the dry season, become parched and burned, so as to resemble sterile wildernesses. The *pampas*, which occupy a large part of the plain of the La Plata, are dotted here and there with palm groves, and in some places overgrown with thistles, or incrusted with salt; but, for the most part, they are covered with rich herbage, feeding countless herds of cattle.

Some of the steppes of Asia are merely sandy plains, bearing a few stunted shrubs, and exhibiting only occasional spots of verdure: others are covered with herbage, and afford good pasturage for the numerous herds of the pastoral tribes that roam over them: others bear saline and succulent plants, or are coated with saline incrustations. The karroos of Southern Africa are tracts of arid clay land, bearing some succulent plants; but the meagre vegetation which clothes them with verdure and adorns them with flowers, during the rainy season, disappears during the heats of summer, giving the country the aspect of a parched and barren plain.

The jungles of India are tracts covered with dense and impenetrable masses of vegetation, crowded and twined together, consisting of thorny and prickly shrubs, of every size and shape, and even canes, which in a few months shoot up to the height of 60 feet, and creeping plants and bushes, which form impassable barriers even to an army.

§ XII.—Passes and Defiles.

The narrow passage by which we enter into valleys, is called a Pass, or Defile; and, as formerly, each valley contained a small independent tribe, or nation, these passes are called by the French, *Portes des Nations*, (Gates of the Nations.) Such are the passes of Caucasus,—the Caspian Passes,—the Pass of Issus, rendered celebrated by the victory of Alexander,—that of Thermopylæ, immortalized by the devoted patriotism of Leonidas and his band of Spartans, and the *Furculæ Caudinæ*, or Caudine Forks, where Rome saw the glory of her unjust arms deservedly tarnished. There is one of these passes between Norway and Sweden, near Skiaerdal, formed by several masses of rock, cut by nature into long parallelograms, which have between them a passage shut in by perpendicular walls. Another of the same kind is at Portfield, (Gate-mountain.) These openings exactly resemble those by which the Hudson River passes through successive chains of mountains, which seem desirous of checking its course. The Cordilleras of the Andes present the most stupendous passes of this kind that are known. They are from four to five thousand feet deep. The lower valleys appear to us under a very different aspect; they widen as they recede from the secondary mountains from which they originate, and gradually lose themselves in the plains. Their opposite angles generally correspond very regularly; but these angles are very obtuse.

§ XIII.—Islands.

Islands of great extent exhibit, on a small scale, the same appearances as continents. The smaller islands, however, deserve a distinct consideration. These may be classed in various ways: they are single, or in groups, or chains. Among low or flat islands, there are some which are only banks of sand, scarcely raised above the surface of the water. Sometimes they consist of masses of shells, or petrifications, as the Isles of Lachov, north of Siberia, which are nothing but masses of ice, sand, and the bones of the mammoth. Many of the islands of the Pacific were formed, or at least enlarged, by polypi, and are composed mainly of coral rocks. Of the more elevated islands, we find many which are of volcanic origin. Such are the Sandwich Islands, the Society Islands, the Marquesas, and several others in the Pacific. In several instances, the volcanoes have continued to discharge lava from their crater, in all directions, until by

slow and gradual accumulation, they have formed those vast and lofty peaks, which serve as landmarks to the distant mariner.

When groups of islands are placed near each other, we may fairly conjecture that they are only the summits of one extensive submarine mass. So, also, when they appear to follow one constant direction, they probably form only the eminences of a chain of submarine mountains. Such, when situated in the same line with the promontory of a continent, may be considered as a continuation of the chain. Thus, it is evident that the Kurile Islands connect Jesso with Kamschatka, in the same way as the Great and Little Antilles connect the two continents of America. But, to make the observation hold, the intervals which separate the islands must either be very small, or be filled up with rocks and shoals beneath the surface, so as to preserve unbroken the continuity of the bases of these submarine mountains. Thus, we must not consider Iceland, the Faroes, and the Shetland Isles, as a continuation of the Norwegian Mountains, because a deep sea intervenes. Their geological structure indicates, that they are rather connected with the British Isles.

§ XIV.—General Arrangement of the Great Mountain Chains, and Aspect of the Continents.

If we draw a line from the centre of Thibet, across Mongolia, towards Ochotsk, and thence towards Cape Tchutchi, on the eastern promontory of Asia, this line will, in general, coincide with an immense chain of mountains which run from south-west to north-east, and everywhere descend very rapidly towards the Indian and Pacific Oceans; while, on the other hand, they extend themselves towards the Arctic Ocean, in plains and secondary hills. The case seems to be the same with the African Mountains. Now we may consider the lofty and steep Mountains of Arabia Felix, as the link which connects the Mountains of Laputa, and the Mountains of the Moon, with the Plateaus and Mountains of Persia and Thibet. Again, from Bhering's Straits to Cape Horn, if we follow the western coasts of America, we shall find one unbroken chain of the highest mountains of our globe. This chain occasionally bends a little into the interior, but more frequently, it closely borders on the ocean with a range of steep and bold shores, and sometimes with the most tremendous precipices. On the other side, the outlet of lakes, and the direction of the great rivers, evidently show that the whole, or nearly the whole, surface of America inclines to the Atlantic Ocean. It follows from these facts, that the greatest chains of mountains upon the face of the globe, are ranged in a circle round the Pacific and Indian Oceans; and, also, that they more frequently exhibit steep and rapid descents towards

that immense basin which they surround, and long and comparatively gentle declivities on the opposite coasts. In short, from the Cape of Good Hope to Bhering's Straits, and thence to Cape Horn, the eye, even of a nice and fastidious observer, cannot fail to discover some links of an arrangement as striking from its uniformity, as from the immense extent of country which it embraces.

Let us now suppose ourselves placed in New South Wales, with our face turned toward the north. We shall see America on the right, and Africa and Asia on our left. These continents, which, not long since, even in imagination, we could not consider as at all approaching each other, being examined from this point of view, form, as it were, one whole, the structure of which exhibits, in its grand features, a most remarkable symmetry. A chain of enormous mountains surrounds a vast basin; this basin, divided into two by a large mass of islands, frequently washes with its waves the base of this great primitive chain of the earth. But when did this immense chain of granite and porphyry shoot up from the bosom of the waters? Or, when did those lofty secondary mountains sink into the depths of the ocean, and by their simultaneous submersion, form that steep and abrupt range of coast, which predominates over our globe?

Let us return to the old continent, and recollect, that the vast regions of India and China, contrary to many theories, are placed to the south of this great girdle of mountains; that the peninsula beyond the Ganges even joins that astonishing group of broken, and intersected countries, which fill the centre of the great basin; and that this is, as it were, the link which connects with the present continent those grand remains of a former continent, which seems to have disappeared.

If we consider, under the same point of view, the whole extent of the two continents, we shall perceive that the greater part of the plateaus and the chains of mountains incline very generally to the Atlantic and Northern Oceans. That extent of waters, vast as it is, appears then, only like a canal compared with the great Pacific; and the steep coasts which border the Atlantic, are nothing in comparison with those of the Cape of Good Hope, and of Gardafui, with the precipices that surround the seas of Kamschatka, of Peru, and of Chili.

It was formerly supposed that mountains increase in height as we approach the equator; but when we remember that the highest of the Himalays—the most elevated in the Old World,—and the highest of the Andes—the most elevated in the New World,—are both beyond the tropics, and that very high mountains have been discovered both in the Arctic and in the Antarctic regions, such an opinion will be seen at once to be quite erroneous.

§ XV.—Table of the Heights of the Principal Mountains in the World.

I. NORTH AMERICA.

Name.	Country.	Height.
Mount St. Elias,	Russian Territory,	17,775 feet.
Popocatepetl,	Mexico, ...	17,717 "
Orizaba,	"	17,374 "
Iztacihuatl,	"	15,705 "
Mount Hooper,	British Territory, .	15,690 "
Nevada of Toluca,	Mexico, ...	15,542 "
Sierra Nevada,	"	15,170 "
Mount Fairweather,	Russian Territory,	14,925 "
Long's Peak,	Indian Territ'y, U. S.	13,430 "
Mount Perote,	Mexico, ...	13,413 "
Volcan de Fuego,	Guatemala, . .	13,160 "
James' Peak,	Indian Territ'y, U. S.	11,500 "
Sierra de Cobre,	Cuba, . . about	9,000 "
Grand Serrania,	Hayti, . . "	9,000 "
Blue Mountains,	Jamaica, . . .	7,277 "
Black Mountain,	North Carolina, .	6,476 "
Mount Washington,	New Hampshire, .	6,428 "
Mount Marcy,	New York, . .	5,300 "
Mansfield Mount,	Vermont, . . .	4,279 "
Peaks of Otter,	Virginia, . . .	4,260 "
Round Top,	Catskill, N. Y. .	3,800 "
High Peak,	" . .	3,700 "

II. SOUTH AMERICA.

Name.	Country.	Height.
Aconcagua,	Chili, ...	23,910 feet.
Sahama,	Peru, ...	22,350 "
Chimborazo,	Ecuador, . . .	21,424 "
Acohuma,	Bolivia, ...	21,286 "
Illimani,	"	21,140 "
Volcano of Arequipa,	Peru, ...	20,320 "
Cotopaxi,	Ecuador, . . .	18,875 "
Volcano of Tolima,	New Grenada, . .	18,020 "
Volcano of Purace,	" . .	17,034 "
Mountain of Potosi,	Bolivia, ...	16,152 "
Pichincha,	Ecuador, . . .	15,924 "
Silla de Caraccas,	Venezuela, . . .	8,600 "

Name.	Country.	Height.
Duida,	Venezuela, . . .	8,280 feet.
Roraima,	Guiana, ...	7,450 "
Organ Peak,	Brazil, ...	7,400 "
Mount Sarmiento,	Terra del Fuego, .	6,900 "
Mount Stokes,	Patagonia, . . .	6,400 "
Itambe,	Brazil, ...	5,960 "

III. EUROPE.

Name.	Country.	Height.
Mont Blanc,	Switzerland, . .	15,739 feet.
Mount Rosa,	" . .	15,210 "
Jungfrau,	" . .	13,672 "
Monte Viso,	Savoy, ...	13,599 "
Simplon,	Switzerland, . .	11,730 "
Mulachazen,	Spain, ...	11,484 "
Penaranda,	"	11,200 "
Malahite Peak,	France, ...	11,168 "
Mont Perdu,	"	10,994 "
Mount Etna,	Sicily, ...	10,874 "
Sierra de Gredos,	Spain, ...	10,552 "
Budosch,	Transylvania, . .	9,593 "
Monte Cornò, or Gran Sasso,	Italy, ...	9,521 "
Monte Rotondo,	Corsica, ...	8,767 "
Mount Guiona,	Greece, ...	8,538 "
Sneehattan,	Norway, . . .	8,120 "
Skagtöltend,	" . . .	8,101 "
Parnassus,	Greece, ...	8,068 "
Taygetus, or St. Elias,	"	7,904 "
Athos,	"	6,778 "
Helicon,	"	5,738 "
Delphi,	"	5,725 "
Riesenhoppe,	Germany, . . .	5,394 "
Snoefials,	Iceland, ...	5,115 "
Ben Macdui,	Scotland, . . .	4,418 "
Ben Nevis,	" . . .	4,379 "
Ben Lawers,	" . . .	4,051 "
Cairngorm,	" . . .	4,050 "
Vesuvius,	Italy, ...	3,932 "
Snowdon,	Wales, ...	3,557 "
Cader Idris,	"	3,550 "
Shiehaillin,	Scotland, . . .	3,514 "
Curran Tual,	Ireland, . . .	3,412 "
Cross Fell,	England, . . .	3,383 "

Name.	Country.	Height.
Hymettus,	Greece, ...	3,378 feet.
Heela,	Iceland, . . .	3,324 "
Helvellyn,	England, . . .	3,313 "
Skiddaw,	" . . .	3,038 "
Stromboli,	Lipari Isles, . .	2,687 "

IV. ASIA.

Name.	Country.	Height.
Kunchinginga,	Hindostan, . .	28,178 feet.
Dhawalagiri,	" . .	26,862 "
Chumalaree,	Thibet, ...	23,929 "
Elburz,	Caucasus, . . .	18,493 "
Ararat,	Persia, ...	17,112 "
Demavend,	"	14,695 "
Lebanon,	Syria, ...	9,517 "
Olympus,	Asia Minor, . .	9,100 "
Horeb,	Arabia, ...	8,593 "
Sinai,	"	7,498 "
Ida,	Asia Minor, . .	5,435 "
Zion,	Palestine, . . .	2,700 "
Carmel,	" . . .	2,250 "
Tabor,	" . . .	2,053 "

V. AFRICA.

Name.	Country.	Height.
Abba Jarrat,	Abyssinia, . . .	15,000 feet.
Cameroons,	South Guinea, about	13,000 "
Peak of Teneriffe,	Canary Islands, .	12,172 "
Bernard,	Bourbon Isles, .	12,100 "
Miltsin,	Morocco, ...	11,400 "
Peak of Fogo,	Cape Verd Islands,	9,154 "
Pico,	Azores, ...	7,613 "
Table Mountain,	Cape of Good Hope,	3,816 "
Diana's Peak,	St. Helena, . .	2,710 "

VI. OCEANICA.

Name.	Country.	Height.
Mouna Kea,	Sandwich Islands,	13,953 feet.
Mount Ophir,	Sumatra, . . .	13,840 "

Name.	Country.	Height.
Mouna Roa,	Sandwich Islands,	13,760 feet.
Mount Erebus,	Antarctic Continent,	12,400 "
Tobreonou,	Tahiti, ...	12,250 "
Mount Ambotismene,	Madagascar, . .	11,500 "
Mount Edgecumbe,	New Zealand, . .	9,630 "
Egmont Peak,	" . .	8,840 "
Unimak Peak,	Aleutian Isles, .	8,593 "
Sea-view Hill,	New South Wales,	6,700 "
Barren Mountains,	Van Diemen's Land,	5,000 "

VII. MEAN HEIGHTS OF MOUNTAIN CHAINS AND CONTINENTS.

Name.	Height.
Himalaya, ...	15,670 feet.
Andes of Bolivia, from 15° to 18° S. lat., Eastern Ridge,	15,250 "
" " Western Ridge,	14,900 "
Table-land of Thibet, ...	11,600 "
Andes of Colombia, from 2° S. to 5° N. lat. . . .	11,380 "
Pyrenees, ...	7,990 "
Alps, ...	7,350 "
Asiatic Continent, ...	1,150 "
South America, ...	1,130 "
North America, ...	750 "
Europe, ...	670 "

DIVISION THIRD.

GEOLOGY, OR DESCRIPTION OF THE SOLID MASSES COMPOSING THE EARTH.

PART I.

GENERAL VIEW OF THE STRUCTURE OF THE EARTH.

§ I.—Preliminary Remarks.

Geology, so far as our present subject is concerned, comprises a description of the inorganic solid masses which compose the earth's crust, and of the organic remains which they contain.* In Geology all those masses are termed *rocks*, whether they are cohesive, like granite, slate, and marble, or loose, like sand, clay, gravel, and common mould. Rocks which originated from depositions in water are termed *aqueous;* those which have been produced by heat are termed *igneous.*

In tracing the nature of those agents that have produced the present condition of the surface and interior of the earth, we find in the foremost ranks *fire* and *water*, two mighty, universal, and antagonizing forces, which have most materially influenced the condition of the globe.

§ II.—Classification of Rocks.

All rocks are divided into two great classes, *stratified* and *unstratified.* Stratified rocks are those which are arranged in regular layers, (generally termed *strata*,) bounded by nearly parallel surfaces. Unstratified rocks are those which exhibit no appearance of regular beds or layers, but consist of masses destitute of any definite form.

* The science of Geology takes a much wider range; but we are concerned only with that part of it which belongs to Physical Geography; and the reader will understand that a similar remark applies to all the subjects of this work.

There are many classes of both kinds. Of the stratified rocks, some are very hard and crystalline, like quartz rock and gneiss; while some are soft and earthy, like peat or clay beds.

The state of the ingredients of crystalline rocks has, in a great degree, been influenced by chemical and electro-magnetic forces; while that of stratified sedimentary deposits,—like the mud beds of deltas,—has resulted chiefly from the mechanical action of moving water, and has occasionally been modified by large admixtures of animal and vegetable remains.

The average aggregate thickness of all the stratified rocks is considered to be at least ten miles. That of the unstratified rocks is unknown; but there is little doubt they extend many hundred miles below the stratified rocks. The latter are arranged by many geologists into *primary*, *transition*, *secondary*, and *tertiary*. But this classification is abandoned by several of the highest authorities; and the terms are so vague that we need not regret the change. The primary denote the oldest and the lowest; and the transition, secondary, and tertiary succeed, in the order in which they are named.

§ III.—Early Condition of the Earth, and Origin of the Unstratified Rocks

There is much evidence to render it probable, that at an early period of the existence of our globe its entire materials were in a fluid state, and that the cause of this fluidity was heat. The form of the earth, being that of an oblate spheroid, compressed at the Poles, and enlarged at the Equator, is that which a fluid mass would assume from revolution round its axis, as has been shown by mathematicians. The further fact, that the shortest diameter coincides with the existing axis of rotation, shows that this axis has been the same ever since the crust of the earth attained its present solid form.

Assuming that the whole materials of the globe may have been once in a fluid state, or even in nebular state, from the presence of intense heat, the passage of the first consolidated portions of this fluid or nebulous matter to a solid state may have been produced by the radiation of heat from its surface into space; the gradual abstraction of such heat would allow the particles of matter to approximate and crystallize; and the first result of this crystallization might have been the formation of a shell or crust composed of oxidated metals and metalloids, constituting various rocks of the granite series *around an* incandescent nucleus of melted matter *heavier than granite*, and such as forms the more weighty substance

of basalt and compact lava. The common consent of nearly all modern geologists, and chemists, refers the origin of this large and important class of unstratified crystalline rocks to the action of heat.

The agency of central heat, and the admission of water to the metallic bases of the earths, and alkalies, offer two causes, which, taken singly or conjointly, seem to explain the production and state of the mineral ingredients of these rocks; and to account for many of the grand mechanical movements that have affected the crust of the globe. The gradations are innumerable that connect the infinite varieties of green stone, syenite, porphyry, granite, and basalt, with the trachytic porphyries, and lavas, that are at this day ejected by volcanoes; and there is little doubt that the fluid condition in which all unstratified rocks existed originally was owing entirely to the solvent power of heat.

§ IV.—Origin of the Stratified Rocks, and of the various Species of Plants and Animals.

Beneath the whole series of stratified rocks that appear on the surface of the globe, there exists a foundation of unstratified rocks, bearing an irregular surface, from the detritus of which the materials of stratified rocks have all been originally derived. The thickness of stratified rocks accessible to our inspection, is very small, compared with the diameter of the earth; but small as it is, it affords certain evidence of a long series of changes and revolutions, affecting, not only the mineral condition of the nascent surface of the earth, but attended also, by important alterations in animal and vegetable life.

All observers admit that the strata which compose the dry land, were originally formed by the aggregation of materials beneath the water, and then brought to the surface; and whatever may have been the agents that caused the movements of the gross, unorganized materials of the globe, we find sufficient evidence of prospective wisdom and design, in the benefits resulting from these obscure and distant revolutions, to future races of terrestrial creatures, and more especially to man.

The detritus, or matter abraded by streams from the first dry lands, being drifted into the sea, and there spread out into extensive beds of mud, sand, and gravel, was subsequently raised into dry land. The forces generally supposed to have been employed, are the expansive powers of heat and vapors, exclusively; and these agents will account for many phenomena: but we cannot see that they will account for the elevation of continents, which we attribute to the *unequal contractility* of the various rocks in cooling. Yet we allow

that igneous agency has been active during every geological epoch, in elevating, more or less, extensive portions of land, as aqueous agency has always been active in depressing them. From the fluid mass of metals and metalloid bases of the earths and alkalies, which were intermingled in a fluid state, the first granitic crust appears to have been formed by oxidation of these bases; and this solid crust supplied the materials of the oldest stratified rocks. The total absence of organic remains in these rocks, supports the theory of gradual refrigeration, and leads us to conclude, that the waters of the first formed oceans were too much heated to have been habitable by any kind of organic beings. In these ancient conditions of land and water, Geology refers us to a state of things incompatible with the existence of animal and vegetable life, and thus conducts us to a period long subsequent to the existence of the earth as a solid globe, when there was yet no vegetable or animal found within its borders. And then recurs the question, *Whence came the first animals and plants?* The bearing of this inquiry on natural and revealed religion, shows that Geology is not that barren science which some erroneously imagine.

In confutation of the theory which explains present phenomena, by assuming an eternal succession of similar preceding phenomena, the discoveries of Geology have established, first, that existing species have had a beginning, and this at a period comparatively recent in the physical history of our globe; and second, that they were preceded by several other systems of animal and vegetable life, respecting each of which, it can be proved, that there was a time when their existence had not commenced. It further explodes the doctrine of a gradual transmutation of one species into another, by showing that one species was immediately succeeded by a different species. It presents to us a beginning and end of several systems of organic life, each affording conclusive proof of the repeated, and separate exercise of miraculous creative power. The oldest stratified rocks not only exhibit no trace of organic matter, but prove that the surface of the earth was so hot during their formation, as to render the existence of any animal or plant impossible for a single minute.

The next series—frequently called the *transition rocks*—are intimately associated with the appearance of organic life. The mineral character of transition formations, presents evidence of the action of water in violent motion; and many of them were deposited in the form of mud and of sand, at the bottom of the sea.

§ V.—Earliest Condition of Organic Life.

Beginning with the animal kingdom, we find the four great existing divisions* to have been coeval with the commencement of organic life, upon our globe. But no higher condition has been yet discovered in transition formations, than those of fish, the lowest class of the vertebrates.

The mollusks, in the transition formation of rocks, afford examples of genera and species that are diffused over the whole earth. The earliest examples of articulated animals, are those afforded by the extinct family of trilobites, which appear to have become extinct before the beginning of the second series, although at one time extremely numerous. The radiates are among the most frequent organic remains in the transition strata, and present numerous forms of great beauty, especially the family of star-fish and fossil corallines.

In the inferior regions of transition series, plants are few in number, and chiefly marine. In the superior regions, land plants are contained in prodigious numbers. The strata in which these vegetable remains have been collected in such vast abundance, have been justly designated the carboniferous order, or great coal formation. It is in this formation chiefly, that the remains of plants of a former world have been preserved and converted into beds of mineral coal, having been transported to the bottom of former seas and lakes, and buried in beds of sand and mud, which have since been changed into sandstone and shell. Thus, by the use of coal, we are brought into immediate connection with the vegetation that clothed the ancient world, before half its surface was yet formed. The trees of the primeval forests have not, like modern trees, undergone decay, by yielding back their elements to the soil and atmosphere that nourished them; but treasured up in subterranean storehouses, have been transformed into enduring beds of coal, which have, in latter ages, become fertile sources of light, heat, and wealth to man. How wonderful the economy of nature's secret workings, and the beneficence of the Divine Lawgiver, who directs and sustains that economy for the happiness of his creatures!

* Naturalists divide all animals into four great divisions; viz.: *Vertebrata*, or animals possessing a skull and back-bone,—*Mollusca*, animals consisting of a soft mass, without either internal skeleton, or articulated covering, such as the oyster and the snail,—*Articulata*, those covered with a series of articulated rings, like the earthworm, the bee, and the lobster,—and *Radiata*, or *Zoophyta*, those whose parts are arranged circularly round the mouth, which is in the centre, such as the polype and the sponge animal. We shall employ the English forms of these terms, which are *vertebrates, mollusks, articulates, and radiates.*

§ VI.—Origin of Soil, Springs, and Salt Mines.

The movements of the waters by which the materials of strata have been brought to their present position, have caused them to be intermixed in such a manner, and in such proportions, as in various degrees are favorable to the growth of the different vegetable productions necessary for the health of man and animals. Solid rocks have been converted into soil by simple exposure to atmospheric agency, and the vicissitudes of heat and cold, moisture and dryness, which reduce the surface of almost all strata to a comminuted state of soil or mould, the fertility of which is usually in proportion to the compound nature of its ingredients. The three principal materials of all strata are, silica or flint, clay, and lime. Each of these, taken singly, and in a state of purity, is comparatively barren; but the admixture of a small proportion of clay gives tenacity and fertility to sand, and the further addition of calcareous earth produces a soil highly valuable to the agriculturist; and where the natural proportions are not adjusted in the most beneficial manner, the facilities afforded by the frequent juxtaposition of lime or marl, or gypsum, for the artificial improvement of soils deficient in those earths, imparts to agriculture half its treasures. Hence, it happens, that the great cornfields and largest population of the world, are situated on secondary and tertiary formations, or on their detritus, composing still more compounds, and consequently more fertile diluvial and alluvial deposits.

Strata of limestone, sand, and sandstone, which readily absorb water, alternate with beds of clay, or marl, which are impermeable to this most important fluid. All permeable strata receive rain water at their surface, whence it descends until it is arrested by an impermeable subjacent bed of clay, causing it to accumulate throughout the lower region of each porous stratum, and to form extensive reservoirs, the overflowings of which, on the sides of the valleys, constitute the ordinary supply of springs and rivers. These reservoirs are not only occasional crevices and caverns, but the entire space of all the small interstices of those lower parts of each permeable stratum, which are below the level of the nearest flowing springs. Hence, if a well be sunk to the water-bearing level of any stratum, it forms a communication with a permanent subterranean sheet of water, and affords plentiful supplies to the inhabitants of upland districts, which may be above the level of natural springs.

During the formation of the secondary rocks, the seas appear to have so superabounded with salt, as to deposit it in immense quantities. Hence, salt mines abound through this series, especially in the new *red sandstone. Had not* the beneficent Creator laid up these

stores of salt within the bowels of the earth, the distance of inland countries from the sea would have rendered this article, of prime and daily necessity, unattainable to a large portion of mankind; but the strata of mineral salt, which are dispersed generally over the interior of our continents and larger islands, obviate the difficulty. Salt is also the most abundant of the saline compounds formed by sublimation in the craters of volcanoes.

§ VII.—Condition of the Earth during the Formation of the Secondary and Tertiary Rocks.

Although the petrified remains of zoophytes, crustacea, testacea, and fish, in the secondary rocks, show that the seas in which these strata were formed, abounded with creatures referable to the four existing divisions of the animal kingdom, yet the condition of the globe seems not to have been sufficiently advanced, to admit of general occupation by warm-blooded, terrestrial animals. The only animals of this kind found in secondary formations, are of the marsupial, or pouched order, such as the opossum and kangaroo. It is now peculiar to North and South America, New Holland, and the adjacent islands. The peculiar feature in the population of the whole series of secondary strata, was the prevalence of gigantic forms of saurian, or lizard-like reptiles. Many of these were exclusively marine; others were amphibious, and others terrestrial, ranging in savannahs and jungles, clothed with a tropical vegetation, or basking on the margins of lakes and rivers. Even the air was tenanted by flying lizards, under the dragon form of the pterodactyle, the most curious of animals. The earth was, probably, then too much covered with water, and those portions of land which had emerged above the surface were too marshy, and too frequently agitated by earthquakes, inundations, and atmospheric irregularities, to be extensively occupied by any higher order of quadrupeds than reptiles.

The tertiary series introduces a system of new phenomena, presenting formations in which the remains of animal and vegetable life approach gradually nearer to the species of our own epoch. The most striking feature of these formations consists of the repeated alternations of marine deposits, with those of fresh water. Throughout all these periods, there seems to have been a continually increasing provision for the diffusion of animal life; and we have certain evidence of the character and number of the creatures that were permitted to enjoy it, in the multitude of shells and bones preserved in the strata deposited during each of the four epochs we are considering. The tertiary series, according to Lyell and Deshayes, contains marine formations divided into four parts, viz., eocene, miocene, older pliocene, and

newer pliocene. The term *eocene* (morning-new) implies the dawn of the existing state of the animal creation. The term *miocene* (less new) implies, that a minority of fossil shells and formations of this period are of a recent species. In formations of the older and newer *pliocene* (more new) taken together, the majority of shells belong to living species, and abound especially in the new.

Alternating with these four great marine formations, above the chalk, there intervenes a fourfold series of other strata, containing shells, which show them to have been formed in fresh water, accompanied by the bones of many terrestrial and aquatic quadrupeds.

§ VIII.—Relations of the Earth and its Inhabitants to Man.

From the statements that have been made in the preceding pages, it appears that five principal causes have been instrumental in producing the actual condition of the surface of our globe. First, the passage of the unstratified crystalline rocks from a fluid to a solid state; secondly, the deposition of the stratified rocks at the bottom of the ancient seas; thirdly, the elevation of stratified and unstratified rocks from beneath the sea, at successive intervals, to form continents and islands; fourthly, violent inundations, and the decomposing power of atmospheric agents, producing partial destruction of these sands, and forming from their detritus extensive beds of sand, of gravel, and of clay; fifthly, repeated oscillations of the land, whereby it was submerged, and again elevated. We shall form a better estimate of the complex disposition of the materials of the earth, which has resulted from the operations of all these mighty conflicting forces, if we consider the inconveniences that might have attended other arrangements more simple than those which actually exist. Had the earth's surface presented only one unvaried mass of granite, or lava; or had its nucleus been surrounded by entire concentric coverings of stratified rocks, like the coats of an onion, a single stratum only would have been accessible to its inhabitants; and the varied intermixtures of limestone, sandstone, and clay, which are now so advantageous to the fertility, beauty, and habitability of the globe, would have had no place.

The inestimably precious treasures of mineral salt, of coal, and of metallic ores, confined as these latter are, to the older series of formations, would, under the supposed more simple arrangement of the strata, have been wholly inaccessible, and we should have been destitute of all the essential elements of industry and civilization. Under the present disposition, all the various combinations of strata, with their valuable contents, whether produced by the agency of subterranean fire, or by mechanical or chemical deposition beneath

the water, have been raised above the sea, to form the mountains and the plains of the present earth; and have still further been laid open to our reach by the exposure of each stratum along the sides of the valleys. The production of a soil fitted for agriculture, and the general dispersion of metals, (more especially of that most important of metals, iron) were almost essential conditions of the earth's habitability by civilized man.

Although the waters, which cover two thirds of the earth's surface, are uninhabitable by man, or any terrestrial animal, yet they are abundantly stocked with animated beings that exult in the pleasure of existence, independent of human control, and in no way subservient to the necessities or caprices of man, while they fertilize the land by their vapors. Such is, and has been, for several thousand years, the actual condition of our planet.

We find certain families of plants and animals existing during every period, and under nearly the same generic forms as those which they present at the present day. Others are limited to particular formations, there being certain points where entire groups ceased to exist, and were replaced by others of a different character. The changes of genera and species are still more frequent.

§ IX.—Volcanoes.

In the state of tranquil equilibrium which our planet has attained in the region we inhabit, we are apt to regard the foundation of the solid earth as an emblem of duration and stability. Very different are the feelings of those whose lot is cast near the foci of volcanic eruptions. To them, the earth often reels to and fro, and vibrates beneath their feet, overthrowing cities, yawning with dreadful chasms, converting dry land into seas, and seas into dry land.

The origin of volcanoes is now generally held to be the action of steam on subterranean lakes of lava, which have probably never assumed the solid form since the whole globe was liquid with heat. The steam is produced from the water which percolates through the earth, coming in contact with the lava; of which it occasionally expels a part on the principle of intermitting springs. The lava is supposed to be from ten to thirty miles below the surface. The flames sometimes emitted from the ground after a storm may probably arise from the action of water on some metallic substances; but the matter ejected from volcanoes proves that their origin is different.

Earthquakes originate from the expansive force of steam which finds no vent; and hence they frequently precede eruptions, and cease afterwards.

Disintegrated lava forms the most fertile of soils, besides furnish-

ing many important materials which are deficient in the older rocks. Hence those terrible commotions answer an important purpose in the chain of events by which the apparent ruin and confusion of certain periods result in the varied beauty and fertility everywhere visible.

PART II.

DESCRIPTION OF THE VARIOUS CLASSES OF ROCKS.

§ I.—Discoveries of Geology.

History, tradition, and observation, combine to prove that the earth's surface is undergoing a perpetual change; the currents of rivers and oceans are forming accumulations of land in some places, and washing away the surface of others. The waters of lakes and seas deposit successive beds of ever-forming rocks; the summits or flanks of mountains, undermined or sapped by rains and frosts, are plunged into the valley below; and lofty mountains and deep valleys are formed by the elevation or subsidence of the surface occasioned by earthquakes.

Geology goes further; it shows us that these changes have been going on in times anterior to historical or traditional knowledge; and by an examination of the structure and position of the layers which compose the crust of the earth, it is able to determine their relative ages and the mode of their formation, whether from alluvial accumulations or by the deposition from aqueous or igneous solutions. Moreover, by studying the animal and vegetable remains which they contain, it proves that the whole, or nearly the whole, of the present land was once at the bottom of the sea, and has been elevated by the mighty forces of nature.

It was long thought to be vain to look for order, or regularity, in the composition and arrangement of the great masses of which the crust of the earth is composed; but we shall see this idea was erroneous.

§ II.—Various Structures of Mountain Rocks.

The principal of these are the following:—(1.) The *compact* structure, in which the mass is uniform, and when broken, exhibits various fractures; as compact quartz. (2.) The *slaty* structure, in which the rocks split readily into layers, as common roofing-slate for houses. (3.) The *granular*, when the rocks are composed of granular concretions, or imperfect crystals; as primitive limestone, or statuary marble. (4.) The *porphyritic*, in which there is a basis, or ground, with imbedded crystals; as porphyry. (5.) *Amygdaloidal*, when the basis contains almond-shaped cavities, whether empty or filled with minerals. (6.) *Conglomerations*, when the rock is composed of fragments imbedded in a basis; as pudding-stone.

§ III.—Definition of Beds, Formations, and Veins.

Any mass of rock different from those around it is called a *bed*. Several varieties are sometimes discoverable in the structure of individual beds: thus, in some, the rock is arranged in columns, as in basalt; in others, in tables, as in porphyry; or in balls, as in granite.

All those rocks which appear to have been formed at the same time, and in similar circumstances, and which agree in position, structure, petrifactions, etc., are said to belong to the same *formation*. *Simple* formations are those principally composed of one rock, as, for example, granite. *Compound* formations are those containing more than one species, as the coal formation, which contains sandstone, slate, limestone, coal, and ironstone.

Veins are tabular masses that intersect the strata, or beds, where they occur. Like the latter, they vary in position and dimensions from an inch to several fathoms in breadth, and to several miles in length and depth. With regard to situation, they are horizontal, vertical, or more or less inclined. Veins appear to have been originally rents, or fissures, traversing the strata, which have been filled by an after process with the mineral matters they now contain.

IV.—Classification of Stratified Rocks.

The stratified rocks are generally divided into the following classes:—

1. *Primitive Rocks.*—The rocks of this class lie under those of the succeeding classes. Countries in which they predominate, are, in general, more rugged and broken than those composed of rocks

of the other classes. The strata of primitive mountains are often highly inclined, a circumstance which contributes to increase the inequalities of the surface of primitive regions. Primitive rocks are of a crystalline nature, and exhibit such characters as indicate formation from a state of solution, in hot waters, and under a heavy pressure. These contain no organic remains, and hence, are inferred to have been formed before animals and vegetables were called into existence. They abound in metalliferous minerals, and no metal has been met with which does not occur, either exclusively or occasionally, in this class of rocks. Gems also occur in great variety.

The following species of rocks belong to this class, viz.: *gneiss, mica slate, clay slate, quartz rock, and primary limestone.* This class affords durable materials for building.

2. *Transition Rocks.*—The rocks of this class, in the regular succession, rest immediately upon those of the primitive class. Most of them are distinctly stratified, and the strata are often vertical, and like those of the primitive class, exhibit the same direction throughout extensive tracts. They are distinguished from primitive rocks by the occurrence of fossil crustacea, shells, and corals. The extensive deposits of limestone, particularly of the variegated kinds, so much prized for ornamental purposes, which they contain, and the ores of lead and copper distributed among them, give them importance in the arts. This class comprises the following rocks:—*graywacke, transition clay slate, gneiss, mica slate, quartz rocks, red sandstone, limestone, and glance coal, or anthracite.*

3. *Secondary Rocks.*—The rocks of this class are, *sandstone, slate, limestone, gypsum, and coal.*

In the primitive and transition classes, geologists have not observed any determinate arrangements among the deposits; but in this class it has been found to prevail throughout the whole series. The following is a sketch of the order of succession, beginning with the lowest and oldest formation.

1. The old red sandstone. 2. Metalliferous limestone, or carboniferous. 3. The great coal formation, which is a compound consisting of sandstone, clay, limestone, coal, and ironstone. 4. Magnesian and Alpine limestone. 5. Variegated sandstone, or new red sandstone, comprising, besides the sandstone, beds of marl, with gypsum, and rock salt. 6. Shell limestone. 7. Red ground, composed chiefly of sandstone, marls, and dolomites, with salt and gypsum. 8. Lias and oolite limestone, and Jura limestone. 9. Weald clay, and purbeck stone. 10. Chalk formation. The rocks of this class are softer and less crystalline than the preceding, and contain more organic remains. These are extremely unlike those of the present times.

4. *Tertiary Rocks.*—In the regular succession, the rocks of this class rest immediately upon the chalk, or uppermost member of the

secondary class. They are looser in texture than those of that class, yet among them, beds occur equally compact with those of the latter. They abound in fossil remains of animals and vegetables, containing many species different from those now existing.

The rocks of this class, are *plastic clay*, *calcaire grossier* or *London clay*, *gypsum* with bones, *superior marine sandstones*, *sands*, and *upper fresh water formation*.

5. *Alluvial Rocks.*—Under this head are included the various calcareous deposits, peat, clays, loams, sands, gravels, and rolled masses or bowlders, which, in the regular succession, rest upon the newest or uppermost rocks of the tertiary class. Remains of vegetables and animals, are of frequent occurrence in this formation. Neither remains of human industry or human bones have been found in the older alluvia, but skeletons and bones of quadrupeds abound. Some of these quadrupeds are of extinct species of existing genera, as the mastodon, megatherium, and others, belonging to existing species.

§ V.—Classification of Unstratified Rocks.

The unstratified rocks all bear palpable indications of having been in a fluid state from heat; hence they are termed *igneous* rocks. They were either protruded through the stratified rocks, which they have frequently fractured and upheaved, or rose through them by the latter sinking down. One kind passes insensibly into another; hence a scientific classification of them is impossible. They may be divided into the four following classes:

(1.) *Granitic.* This includes the various kinds of granite, syenite, porphyry, and claystone.

(2.) *Trappean*, comprising basalt, greenstone, trachyte, hypersthene, and hornblende.

(3.) *Serpentinous*, including serpentine, ophite, ophicalce, and diallage.

(4.) *Volcanic*, embracing the productions of modern volcanoes. The principal are the various kinds of lava, obsidian, pitchstone, and pumice.

Those first mentioned are the oldest and most crystalline. These are extremely hard, and form the most durable materials for building. They are found only among the older stratified rocks. The latter classes are much softer and decompose more rapidly. Some of the most picturesque scenery in the world is owing to the presence of the trappean rocks, such as Fingal's Cave, in Scotland, the Giant's Causeway, in Ireland, and the Palisades on the Hudson, in New York.

Most kinds of igneous rocks were erupted at different periods. *The granite* predominated during the formation of the older stratified

rocks; and it never appears higher than the chalk, and seldom so high. The older rocks appear to have cooled slowly and under pressure, no doubt that of the stratified rocks and deep waters: the more recent generally cooled rapidly and without pressure; hence they are uncrystalline and cellular.

§ VI.—Various Positions of Rocks.

Rocks rest upon one another in every possible manner, horizontally, and at every angle. Sometimes in moderate elevations, and especially in lowlands, the different strata preserve, for hundreds of leagues, a parallel position; thus the limestone or calcareous strata, (containing numerous shells,) upon which the city of Paris is built, extends across what is called the Isle of France, as far as Belgium. The gypseous strata of Montmaitre, and of the heights of Belleville, have the same degree of elevation, though separated by a valley.

A ridge of granite seems to extend straight from the Limosin to Cherbourg, in Normandy. Another girdle follows the valley of the Upper Loire, from Mount Cénis to Saint Etiénne, a space of 70 leagues. In the Island of Rugen, in Pomerania, in the Danish Island of Moen, and at Stevens', in Zealand, the strata of chalk and flint correspond to each other, though an open sea flows between their bases.

Amid this tranquil regularity of formation, what traces of destruction at once alarm and delight the observer of nature! In the plains and on high mountains, we meet with strata that have been entirely inverted, or partly shifted from their position, bent into every shape, crooked and curved, and returning upon themselves. The Mountain of St. Gilles, near Liége, exhibits all these anomalous appearances. We find considerable strata in Mount Jura, which, having been overturned and pushed forward upon others, have stopped in a position so precarious that the application of the least force would put them in motion again. The Alps exhibit an extraordinary example of disorder and confusion, that strike the spectator with awe and wonder. We discover pyramidal mountains, like the Needle of the South, the layers of which are ranged round the axis of the pyramid, like the leaves of an artichoke. Nant D'Arpénaz presents to our view a sort of hemisphere, composed of regularly curved strata. At every step, the rules which appear generally followed, are broken, and set at defiance by the greatest possible diversity. If Mont Blanc be composed of enormous vertical blocks, Mount Rosa, equally gigantic, presents only horizontal strata, a little inclined.

Rocks are frequently intersected by fissures and cavities more or

less considerable. Some consist of interstices left between two ancient rocks, at the moment of their crystallization; the great majority appear to owe their origin either to the retiring or sinking of the earth. The first of these causes, viz., the retiring of the earth, has considerably increased them in the calcareous mountains of secondary formation. They are less prevalent in gypsum. Some of these fissures have been filled with metallic substances; some by the filtering of water impregnated with stony matter; others by incrustations; others by alluvial minerals, by vegetable and animal earths: some have remained open and formed ravines, precipices, abysses, when they are open to the sky; or caverns and grottoes, when they have walls or a natural roof.

§ VII.—Caverns.

The dimensions of caverns have generally been exaggerated, yet the dimensions of some are in reality extraordinary. The depth of the cavern of Elden Hole, near Castleton, in England, has not been discovered, though sounded with a line of more than 9,600 feet. Near Frederickshal, in Norway, there is a hole into which a stone being thrown, it is two minutes in reaching the bottom, from which it has been surmised that the depth must be upwards of 11,000 feet. Among the numerous caverns of Carniola, that of Adelsburg is said to afford a subterraneous walk of two leagues. Many caverns are remarkable for various natural curiosities. There are some from which, in summer, there issues a wind of an icy coldness, with an astonishing force. Mount Eoto, in Italy, is an example of this. The little communication which some caverns have with the external air causes them to change their temperature long after that of the air becomes changed on the surface of the earth.

The most interesting caverns, and the most curious, for their natural productions, are those from whose roofs water impregnated with calcareous matter has dropped and formed stalactites. This calcareous substance is formed by drops of water, which, in falling from the roofs of caverns or grottoes, either becomes hardened by degrees and remains suspended from these vaults, in the shape of long crystals or icicles, or falls to the ground and assumes a thousand fantastic forms, often representing various vegetables or animals. The latter kind are distinguished by the term *stalagmites.* It is to this circumstance that the grotto of Antiparos owes its celebrity.

The naturalist prefers those caverns which contain petrified bones, as these inform him of the revolutions and former condition of animal life on the earth. Some caverns contain the remains of

certain species of marine animals, which appear to have retired thither when they felt themselves about to expire. There are caverns which contain deep pits of water, or wells, sometimes so extensive as to acquire the name of subterranean lakes. There are others from which rivers derive their source, while some are known to receive very considerable streams, which lose themselves in the interior. Such are the innumerable cavities of the Julian Alps, in Carniola and Croatia. It is to similar reservoirs that we must attribute the periodical disappearance of the Lake of Cirknitz. There are some caverns in Norway, where, as you walk upon an arched calcareous floor, you hear the roar of invisible torrents beneath your feet. Many caverns in Russia, and Siberia, have been evidently formed by means of water, and even masses of ice.

Volcanic caverns form a distinct class. That of Surtur, in Iceland, which is 5,034 feet long, has three of its sides or walls covered with a greenish-black varnish, formed by a volcanic vitrification. Long pieces of lava are suspended from the roof, which is so full of crevices as in many places to admit the rays of the sun. The most magnificent of all the known caverns, is, doubtless, that of Fingal's Cave, in the Island of Staffa, on the west coast of Scotland. Thousands of majestic columns of basalt support a lofty roof, under which the sea rolls its waves, while the vastness of the entrance allows the light of day to penetrate the various recesses of the cave.

Many phenomena, especially earthquakes, appear to indicate the existence of much more considerable subterranean cavities, than those which are known to us. The unknown is now banished from the land of science, and is become the exclusive patrimony of romance-makers; and we must, therefore, acknowledge a perfect unacquaintance with their nature.

§ VIII.—Veins.

The small fissures which pass through the masses of rocks, which we call by the general name of veins, though they appear to the imagination less striking than caverns, present to the eye of reason and of science a still more complicated enigma. The essential character of a vein is, that of cutting, or passing through a mass of rock, in a direction more or less different from that of the strata, or layers, of which the rock or mountain is composed; and being filled with a mineral substance different from that of which the rock itself is formed. We sometimes find veins of twenty or thirty feet in thickness, while others are less than an inch thick. Some continue for the space of several leagues, others divide, and disperse themselves in smaller veins. There are cases in which the veins, having passed

through many strata, suddenly break off at the commencement of a stratum of a particular sort, and re-appear on the opposite side, exactly in the same direction, and of the same thickness which they had at first. The general line of veins is rectilinear, but without any preference as to its direction. The matter with which the vein is filled often contains metallic ores, and is then called *gangue.* There is scarcely any mineral that is not found in some vein or other, more or less abundantly. Some, also, contain petrifactions, which seem to prove, that these fissures were originally empty, and had been filled from above, by means of a fluid loaded with various substances, which it deposited in them. This is the opinion of the celebrated Werner; but it is now rejected by all geologists of any note; and it is considered that all veins were either filled from below, or separated from the rock by chemical or electric action.

§ IX.—Thickness of Strata.

The thickness of strata differs as much as their inclination or position. In the south of Sweden there is a bank, or bed of trapp, which is in many places one hundred feet thick, and in the Alps there are some masses still thicker; but it is not agreed, whether these masses are to be regarded as regular strata. Many of the middle class of mountains contain beds of mineral, or rock-salt, of alum, and of coal, thirty or forty feet thick. There are also some strata of coal near Liége, not more than one inch in thickness. White and black marbles are found in thicker strata than those which are variegated; and in general, those substances which are least compound, 6r mixed, are found in the greatest masses. The devonian, or old red sandstone of England, is 10,000 feet thick. In Mexico or Peru, there are masses of porphyry, which are from 9,000 to 12,000 feet thick.

§ X.—Influence of Geological Structure on Soil and Scenery.

We have already seen that the older igneous rocks decompose much more slowly than the newer: the same is true of the stratified or aqueous rocks. Hence, countries whose surface consists of primary rocks are barren, and those composed of tertiary rocks are generally fertile. As volcanic rocks are seldom found overlying the primary, the unproductiveness of the latter is not aided by the former, whereas tertiary and alluvial deposits are often fertilized by the presence of *disintegrated lavas.* All soils, except the small quantity which consists of decayed organic matter, consist exclusively of disintegrated

rocks. Hence the close connection between the geological structure and productiveness of a country is at once manifest. The age of rocks, however, is not a perfect criterion either of the degree of their decomposibility, or of their value when decomposed. Some limestones, for instance, decompose more rapidly than sandstones of more recent formation; and they produce a better soil, because sandstone consists mostly of silica, which enters very sparingly into the composition of plants or animals, while lime enters largely into the composition of both.

The highest mountains generally consist of primary rocks, frequently intermixed and overlaid with masses of the unstratified, as among the Andes. Although the soil is barren, their air is pure, their scenery grand and impressive, and their mineral wealth is often very great. The mountains formed of this class are not only lofty, but generally precipitous and steep, and abound with sharp peaks and yawning chasms.

The secondary rocks give a peculiar and characteristic appearance to the mountains which are composed of them. Their outlines are less broken than those of the primary mountains, their summits less lofty; but vegetation displays its richness upon their gently inclined sides of chalk and clay, covered very frequently with a layer of marl, and filled with the remains of animals and vegetables, different from those now existing. The argillaceous slate bears the marks of an entire vegetation, anterior to the present constitution of the globe. In the marly, bituminous slate we meet with petrified fish, and many impressions of aquatic animals; and the calcareous rocks contain the bones of quadrupeds. These three strata, and others which are analogous to them, frequently succeed each other, in such a manner, that the remains of the vegetables are placed below, and those of the quadrupeds, near the surface.

In the secondary rocks are found mineral salt, saline springs, mineral waters, layers of coppery slate, alumine, calamine, bituminous earths, petroleum or rock oil, naphtha, mineral tar, and especially coal. All these substances are accumulated in layers and beds, the succession of which constantly varies, but which all belong exclusively to secondary mountains. On the other hand, these mountains contain no metallic veins.

Tertiary rocks are found chiefly in low grounds, resting upon the older rocks, generally the secondary.

Tufa, which is formed by the re-composition of the particles of a primitive rock, conglomerates, or breccias, which are heterogeneous compounds of the fragments of rocks united by a cement of tufa, clay, sand, or gravel, are common in this class of rocks; and they contain abundant remains of large quadrupeds, and other analogous animals now unknown in a living state.

In the drift formation, which is a part of this series, are chiefly found gold and diamonds. The soil of such rocks is generally fertile, the surface flat, and the scenery monotonous.

Alluvial tracts are always fertile, and nearly a dead level, such as we often find along the banks of rivers. The organic remains they contain are those of existing species; and they are the only rocks in which any human remains have been found, save in a state of burial. Such rocks always consist of the same materials as the higher grounds over which their waters flow; and these often wash down, and deposit among them valuable minerals. The soil of such rocks is at once the most fertile and the most unhealthy.

§ XI.—Pebbles.

All the banks of rivers and lakes, and the shores of the sea, are covered with pebbles, rounded by the waves, which have rolled them against each other, and which often appear to have brought them from a distance. There are also similar masses of pebbles found at a very great elevation, to which the present sea appears never to have been able to reach. We find them in the Alps at Valorsina, more than 6,000 feet above the sea level; and on the Mountain of Bon-homme, which is more than a thousand feet higher. There are some places little elevated above the level of the sea, which, like the famous plain of Crau, in Provence, are entirely paved with pebbles; while in Norway, near Quedlia, some mountains of a considerable magnitude seem to be completely formed of them, and in such a manner, that the largest pebbles occupy the summit, and their thickness and size diminish as you approach the base. We may include in the number of these confused and irregular heaps, most of the depositions of matter brought by the rivers into the sea, and left on the banks, and perhaps, even those immense beds of sand which cover the centre of Asia and Africa; and in general, it may be said that the tertiary rocks very nearly approximate to these confused accumulations.

§ XII.—Lava and Basalt.

Lavas are the well-known product of existing volcanoes, which are found spread above all other strata, around the craters which have ejected them, like so many streams around one common source. The black-looking torrents of these substances sometimes assume the appearance of crystallization, or a separation into laminæ, or into roundish blocks. Sometimes they are compact, and sometimes porous. They are often only one mass of scoriæ, or ashes, united by a sort of

cement, and form what we may call volcanic tufa. The strata, or layers, which we observe in lava, and which are commonly separated by thin intervening layers of vegetable mould, indicate the number of volcanic eruptions which have successively produced those different strata.

None of these appearances are common to those celebrated substances known under the name of basalt, which is only an older kind of lava. This substance is seen in the form of prismatic columns, sometimes elevated perpendicularly, as in the Cave of Fingal, and the Giant's Causeway; sometimes inclined towards the horizon, at different angles; sometimes lying horizontally, ranged like logs of wood, and enclosed in fissures, as in the Faroe Islands, or free and unconnected like the basaltic circle, in the Island of Mull. But it is never found overlying tertiary rocks.

§ XIII.—Drift Formation.

The fragments of granite, and other rocks, thrown here and there, upon secondary and tertiary rocks, exhibit a phenomenon as indisputable as it is astonishing. All the chains of Mount Jura; all the mountains which skirt the Alps; the hills and even the plains of Germany and Italy, have blocks of granite scattered over them, frequently of large dimensions. The same phenomenon is also repeated in the plains of Russia and Poland, Denmark and Sweden; and it is very common in North America.

Jutland is so full of these fragments, that the inhabitants use them for enclosures for houses and for churches. These blocks are rounded by the action of water. In Lymfiord, a Gulf of Jutland, and at some points on the western coast of that peninsula, sharp peaks of granite shoot up from the bottom of the sea. But what is most remarkable, is to see enormous masses of granite lying upon the summits of mountains, some of which are near 6,000 feet above the level of the sea.

Such phenomena are observable all over the northern hemisphere, to the 40° of N. lat. The rocks of this kind deposited in one place, are sometimes 30 feet thick. They are of various sizes, some weighing many tons, and some being small pebbles frequently mixed with sand. The whole appears to have been drifted or swept from the north by a powerful rush of waters, which probably arose from an elevation of the bed of the Arctic Ocean. The large blocks, (some of which were carried several hundred miles, and across deep valleys,) were probably floated on icebergs. Geologists differ in the particulars of their theories, but all agree in making flowing water and ice the agents.

PART III.

ACCOUNT OF SOME OF THE REVOLUTIONS WHICH HAVE OCCURRED ON THE SURFACE OF THE GLOBE.

§ I.—Preliminary Observations.

Of the many changes which have ever taken place in the structure and appearance of the earth, some are palpable and undeniable, while others are less obvious, and only to be learned from extensive observations and long chains of reasoning. We intend, at present, to confine ourselves to the former of these: and when the agencies now in operation, and the changes which have unquestionably taken place, are well understood, we shall occupy the vantage-ground for extending our researches, if we are so minded, to those other changes, the knowledge of which discloses the physical history of this planet since first the elements of primary chaos were set in motion by the Great Creator.

The atmosphere generates meteors, whose slow but constant effects, by accumulating from age to age, must ultimately lead to most extensive changes. The winds, which root up entire forests, have, at some remote period, served in laying the foundations of coal mines. The rains, by running down the sides of mountains, bare and harden them in some parts, while in others, they increase their elevation. The hail and snow, by accumulation, produce masses whence flow impetuous rivers, which excavate the valleys. Sometimes the mountain tops are furrowed by thunderbolts, which rend their rocks. The air itself is possessed of a considerable dissolving power, which ultimately decomposes all known substances. The most solid rock is cleft and divided into stones; these crumble into gravel, or dissolve in sand, which are carried by the winds and waters to a great distance. The succession of heat and cold, drought and humidity, accelerates that slow disintegration which is constantly going on before us. The wind disseminates the seeds of flowers, and they germinate in distant lands; it transports whole clouds of volcanic ashes, and holds in solution, a great number of watery, saline, and earthy particles. Thus the air contributes to change the surface of the earth. Its action is also especially perceptible, in the constant extension of moving sands, the effects of which have been severely

felt in many parts. In Greenland, the famous ridge of pure ice, named the *Iceblink*, is situated between two promontories of moving sand, with which the wind strews vessels more than 12 leagues distant. Thus the phenomena of the African Deserts, are met with near the Pole.

Man's industry, though apparently feeble, changes the face of nature. Here he clears away forests, and there he renews them; here he drains lakes, and there he forms them; here he forms artificial mountains, and there he levels those raised by nature. This shows what great effects may be produced by a continuance of small efforts.

§ II.—Changes produced by Vegetation.

Aquatic plants often change a marsh into a damp meadow. These are such as the *hippuris*, the *utricularia*, the *equisetum*, and different rushes, which form, by their interwoven roots, a floating tissue upon muddy water. Next, the *sphagnum palustre* is diffused over the surface, absorbs the water like a sponge, and creates a bed for the briers and lichens, which thicken and raise the soil by their annual depositions. At other times, the expanse of a tranquil bay is peopled by water lilies, the *arundo*, *phragmites*, and other plants which retain the earthy particles cast up by the waters. As soon as this mud has acquired a little solidity, we see the willows spring up, and osiers, and other trees which prefer an aquatic soil. Vegetation contributes in other ways to change the appearance of the earth. That slender plant, the moss, which mounts up the walls of a deserted building, by being repeatedly decomposed and renovated, will, some ages hence, have covered and even buried beneath it, those stately piles which were reared by luxury for royal abodes. The remains of the vilest animals are collected in heaps, where the thrones of monarchs once glittered with splendor. Brambles cover the temple of Jupiter, and the towers of Babylon lie hid and mouldering beneath the grass.

§ III.—Degradation of Land by Aqueous Agency.

Mountains sink down or separate into fragments, from the agency of other causes than earthquakes or volcanic explosions. The waters of a rapid river, a lake, or even of a subterraneous current, consume and secretly undermine a mass of rocks or solid earth. The beds of sand, gravel, clay, and chalk, which serve as a support, are dissolved or swept away; an excavation is formed, and the superincumbent

mass of earth or rocks sinks down by its own weight. Sometimes there is a fissure, by means of which part of the mountain is detached from the principal mass, and overturned in consequence of being deprived of its natural support. These kinds of fissures are, in argillaceous rocks, merely the effects of dryness.

In granite rocks, they appear to arise from the decomposition of certain laminæ, of a less powerful crystallization, acted on by the oxygen of the atmosphere. The granite of Finland, named Rapahiwi, is decomposed, whenever there predominates in its composition ferruginous or sulphuro-ferruginous mica. Thus the mountains may be destroyed even by the influence of that imperceptible humidity which is inherent in all terrestrial substances.

The action of water is greatly assisted by frost. It enters the fissures of rocks, and by freezing there, gradually separates their parts till some roll down into the valleys, or are carried away by streams. The degrading action of water is particularly powerful on cultivated land, because the surface of the earth is loose and unprotected by roots or creeping plants. At first sight, we might suppose that the degradation of land would be very rapid within the tropics, owing to the violent rains and floods: but the thick vegetation and matting of roots and plants afford such a strong protection that the land seems generally to be less affected by the waters than in many parts of the temperate zones.

The degradations which occur from excavations, happen annually in mountainous countries, along rivers. It is thus that the Rhone has formed the vault in which it seems to hide itself or lose itself. It is thus that the Adige swallowed up the town of Neumark and others, in 1767. In the south of Norway, the rapid Glommen descends from the summit of the Dofrine Mountains towards the North Sea, and forms a little above its mouth the fine Cascade of Sarpen. The eddy of the waters from this cascade has formed under its bank a subterranean lake, 600 feet deep. The Castle of Borgne was engulphed in this excavation, and disappeared, so that nothing appeared in its place but a lake 800 feet long, and 300 to 400 broad. The disaster of Pleurs, in Chiavenna, arose from a similar cause. Rivers and springs without number wore away the foundations of Monte Conto. In 1618, the masses of rock which composed the mountain separated from each other, and rolled upon the town, which they completely overwhelmed; and a lake occupied the site of 200 houses.

§ IV.—Origin of Subterranean Forests.

The plains experience depressions of another kind. The platforms of turf suspended upon water sink under the weight of forests, houses, and inhabitants. Ireland frequently sees the number of its lakes increased by the sinking of its bogs. It is to these that subterranean forests owe their origin in some degree. Some are formed like those in Lincolnshire, England, by the sinking down of marshy coasts, and by ancient invasions of the ocean; others, like those discovered near Morlaix, owe their subterraneous situation to changes anterior to the present epoch, but are met with generally in peat grounds. In the Isle of Man, in the midst of a marsh 20 feet deep, fir trees are found still on their roots. Near Asarp, in West Gothland, there are two peat bogs, composed of a thick mud and a slight turf. We discover there a great quantity of trunks and roots of trees, which are carried off every year for fuel; the following year they are equally abundant, which arises unquestionably from an immense collection of trees buried in the ground, and raised to the surface by the annual thaw.

§ V.—Formation of Lakes.

Many lakes are formed in Prussia and Poland. That of West Friesland was formed in the 12th century. By degrees there was formed on its surface a crust of slimy, peaty substances, which, in their turn, were covered with vegetable mould. This crust is now strong enough for a carriage to pass over it, and to be labored, sown, and reaped. At the same time the inhabitants have only to make two or three holes, four feet deep, to find water necessary for steeping their flax.

Terrible disasters mark the existence of subterraneous lakes, where no one suspects them. In 1792, a lake was formed in the town of *Lons Le Saulnier*. It is supposed that this was an old pond of brackish water, on which there was formed a pellicle, then a slight vegetable crust, then ground apparently solid. But a drought having made the subterranean waters fall, this crust was deprived of support, and sunk down. Mount Jura presents a number of vestiges of similar sinkings. The Pyrenees, another calcareous chain, exhibit them in as great abundance. The Julian Alps, where the famous Lake of Cirknitz is, contain in their numerous caverns many similar reservoirs.

§ VI.—Landslips.

There is another species of catastrophe which is not less extraordinary in its causes, than destructive in its effects; and this happens, when one bed of earth or rock slides over another bed without breaking, or separating into pieces. An example of this may be cited in the slip that happened at Solutre, near Macon. After some great rains, the strata of earth which lay upon the Mountain of Solutre, slid along over beds of calcareous stones, which compose the body of the mountain. They had already advanced several hundred yards, and the village was about to be buried in ruins, when the rain ceased, and the mass of earth was arrested in its progress. A still more astonishing example is found in a part of the mountain Goima, in the Venetian Territory, which detached itself during the night, and glided along with several houses, which were carried into the neighboring valley. In the morning, the inhabitants, on awaking, found themselves at the bottom of a valley, instead of being on a mountain: and this happened so gently, that they did not perceive it till next morning.

A landslip often occasions a lake, by damming up a valley. These avalanches are often occasioned by volcanic shocks and earthquakes. They are also, in several cases, owing to heavy rains washing away part of the rock's support. They might sometimes be prevented, by cutting drains and canals in the sides of mountains, to let off their superfluous waters, and by dikes, walls, and deep ditches, to stop or weaken their movements. Landslips are not uncommon in the Northern States; and our readers are probably well acquainted with the details of that which happened at the Notch in the White Mountains, in 1826.

§ VII.—Giant's Cauldrons.

Another singular phenomenon occurs, with no outlet, called in Sweden, *Giant's Cauldrons*. These are singular excavations, sometimes of a spiral form, having their sides very smooth, and situated on the sides of mountains, and frequently containing, in the centre, a rounded stone. Several of these have been observed in the United States, near Fort Nicholson; several occur also in Siberia and Switzerland; but there they are met with chiefly in gypsum, or in limestone rock. In America they exist in granite. They are supposed to have been formed by running waters, which had become engulphed there, and had imparted a rotatory motion to a stone detached from a neighboring rock. In admitting this explanation, the

's Cauldron in Sweden would prove the fact, that there was a when granite was not harder than gypsum—at least, in some ties.

§ VIII.—Drying up of Lakes.

re are many lakes which hold in solution saline, earthy, metallic, ituminous substances; and these form sometimes simple de- : at other times they are precipitated to the bottom of the lake mical action. The different gases and acids with which their are charged, may give rise to crystallization. The remains of ings that live and die in these waters, create calcareous beds th. Trees and vegetables are carried along by the waters, rm floating isles, which, by degrees, unite together, and either the lakes with a crust of earth, or by sinking, elevate their bed. hus the lake is gradually filled up. In all mountainous and y countries there are numerous instances of small lakes being up by these causes. We may, therefore, safely infer, that the ion of several extensive plains is to be ascribed to the drying inland seas, or great lakes, as for example, part of those which on the Caspian Sea. Indeed the fact is undeniably proved in cases, by the materials of which the plains are composed, and ganic remains which they contain.

§ IX.—Changes produced by the Sea.

ery long experience, of more than twenty centuries, sustained torical facts, seems to prove that the present sea, considered as ntity, is in a state completely stationary, so that the evapora- its waters is equal to the quantity with which the rivers aug- t, and its extent is neither diminished nor enlarged. But local stances, like the clearing of waste land, the destruction of , and the choking up of rivers, may, for a time, alter the level nd seas. Other local or temporary causes may produce the n the ocean; that is, not a change in quantity, but small os- ns, which, making the ocean retire, by subverting the equi- n of the waters, occasion the formation of new ground on one nd on the other, invasions of the sea upon the land. These s, however, are too limited to affect the form of great conti-

present sea makes an effort in two ways, to change the form banks: 1st, it creates new lands, by depositing sand, gravel, and marine plants, and by casting up, and by retaining the nd *other substances brought* down by rivers; 2d, by under-

mining the mountains which border on it, and thus causing them to fall. The seas of Europe will exemplify these changes.

Along the eastern coasts of the Mediterranean Sea and its gulfs, there is but little increase of land. The Island of Tyre, however, has been united to the continent by marine deposits. At the mouth of the River Pyramus, in Cilicia, a bed of sand has extended the modern coast six miles beyond the ancient; and similar effects have occurred on the southern shore of Asia Minor, where the coast is flat. The inhabitants of Miletus and Ephesus have several times changed the situation of their respective cities, to follow the receding sea. On the other hand, it is alleged, that the sea makes encroachments upon Istria and Dalmatia, columns and pavements in Mosaic being there found under the waters.

The western coast of Italy presents, in a small space, two phenomena of contradictory appearance. The Pontine Marshes now cover part of the Appian Way, while at the month of the Tiber, we perceive land that was not there in the time of the ancient Romans. It is not the sea, but the rivers, which, having been choked up at their mouths, cover the Appian Way. In the same way, if the renowned villas of Baiæ are now found buried beneath the water, the reason is, that these edifices, once the abodes of luxury and ostentation, were built at first in the midst of the present sea. On the coasts of Spain and France, the Mediterranean has receded. Aigues Mortes in Languedoc, was formerly near the sea; now it is 2 leagues, or 6 miles, distant. The port of Barcelona becomes every day less deep.

In the Gulf of Venice, very remarkable changes have occurred. Ramazzini, having observed that all the country round Modena is suspended over a subterraneous lake, and that a great number of shells are to be found there, is persuaded that Lombardy has, in a great measure, been formed by the combined deposits of the River Po, and the sea. The Po used to inundate whole provinces, but has been confined by dikes, which have elevated the bed of the river, so that the level of its waters is now raised several feet above the lands which surround it. The grounds near Ravenna have sunk so low that the pavement of the Cathedral is only six inches above the level of high water; and the land is extended so much, that this town, formerly situated in the midst of canals and marshes, and furnished with an excellent port, is now three Italian miles from the sea, and surrounded by meadows and fields.

The sum of additions made to the land on the shores of the Mediterranean is supposed to be more considerable than the encroachments of the water.

A great many celebrated harbors retain precisely the same position they always had in early times. The ruins of Herculaneum touch the sea, and so they did in the time of Strabo.

The Atlantic Ocean has made some addition to the land upon the coasts of France, and contributed to raise the level of those sandy plains which reach from Bordeaux to Bayonne. Several bays have been filled up, and the Adour River obliged to find a new outlet to the sea. A district between La Rochelle and Lucon, and, in general, all the marshes of La Vendée, have been gained from the ocean. But near Dob the sea is regaining possession of the lands which formerly belonged to it.

We see a striking example of those changes to which the action of the sea upon the land appears to be subject, on the coasts of Holland. In the remotest periods to which history extends, these countries were immense marshes, for which the sea and rivers mutually contended. The first deposited sand, the latter mud; and thus were formed the more elevated grounds, which were, in some measure, habitable. Human industry directing the course of the rivers, checked the fury of the waves by immense dikes, and thus created a country in the bosom of the waters. There still remain lakes, bogs, and marshes; the rivers silently undermine these ill-consolidated grounds, and the sea penetrates them through the large openings of the rivers.

On the other hand, the sea brings to the shores of the main land a great quantity of greasy mud, clay, and sand; and when these substances have acquired some consistency, the ground is enclosed with dykes. The soil thus formed becomes so fertile, that in a few years it indemnifies the cultivators for all their labor and expense.

On the coasts of Jutland, the sea has filled up with sand several gulfs which afforded a retreat to pirates, and it has probably formed the isthmus that now divides Jutland from the Gulf of Fiord, which was formerly a strait. A part of the northern and western coast of Jutland appears to owe its formation to the sea, which, by accumulating sand, has made an unbroken coast of what was once a chain of islands.

PART IV.

MINERALOGY, OR DESCRIPTION OF THE CONSTITUENTS OF ROCKS, AND OF THEIR PRINCIPAL COMPOUNDS.

---

§ I.—Preliminary Observations.

The science of Mineralogy discusses the properties and relations of all minerals: but Physical Geography takes cognizance only of such minerals as enter largely into the composition of rocks, or such as are of general interest on account of their great utility; and even of these, it describes only such properties as tend to unfold the structure of the earth's crust. It neither describes those corpuscular properties of minerals which belong to chemistry, nor those mechanical properties which belong to general physics and meteorology. It is to be understood, then, that the present subdivision treats of *geographical* mineralogy only.

§ II.—Limestone, or Carbonate of Lime.

Limestone, a chemical compound of lime and carbonic acid, is a very abundant substance on the earth. It belongs to every geological epoch, and to every soil. Among the primary rocks, it constitutes one of the principal formations. In this series it is seen in its pure state, in immense beds, the peculiar character of which is a laminated or scaly texture, which indicates a confused crystallization. It abounds still more in the secondary rocks; and it is found also in the third order, combined with clay, with which it constitutes the various marls.

It forms, also, vast beds in the state of *chalk*, frequently accompanied by large masses of calcareous marine shells, compressed together, and broken. We are, therefore, led to consider chalk as a very ancient product of the altered and obliterated remains of shell fish. It is well known that the madrepores, and other polypi of the equatorial seas, form chalk continually in great quantities. The port of Bantam was shut up in less than a century, by rocks of coral formed by polypi. Limestone is discovered, mixed with flints and colored *marbles*, in alluvial soils, where it has been detected by the explosions

that have taken place. There are, however, countries where chalk is not found; where, hitherto at least, it has been rarely seen, as for instance, in the neighborhood of the Cape of Good Hope, and in the granite and volcanic Peninsula of Kamschatka.

The carbonate of lime, confusedly crystallized, forms the building materials of France. When it possesses a finer grain, it forms a sort of marble, of no great value. According as it becomes harder, and purer, and smaller in the grain, it receives a much finer polish, and is better fitted for the chisel of the sculptor. It is then properly called *marble*. White statuary marble from Carrara, in Italy, is esteemed the purest of any. Pure carbonate of lime is always white. The colored marbles are formed of calcareous matter, mixed more or less with extraneous substances. Every country possesses its peculiar species of marble.

Crystals of the carbonate of lime, under the name of *calcareous spar*, are found generally in calcareous subterraneous cavities, and in all its veins. They serve to ornament every cabinet of mineralogy. Of stalactites we have already spoken.

Calcareous alabaster differs from marble only in being less pure, more variegated in its colors, and somewhat more transparent.

§ III.—Sulphate of Lime and Magnesia.

Sulphate of lime, or lime combined with sulphuric acid, is commonly called *gypsum*, and sometimes *plaster stone*, and *plaster of Paris*. When crystallized, it is called *selenite*. This stone is divisible into brilliant and transparent laminæ. It was used by the ancients, instead of glass, for windows. It very much resembles foliated mica, yet it is totally different in composition. Compact sulphate of lime, fine, close-grained, and of a beautiful white color, constitutes *gypseous alabaster*, or *alabastrite*, which has so often afforded the poets a term of comparison to express the whiteness and snowy purity of the complexion. Sulphate of lime often forms hills or little mountains, and sometimes it is found in strata, among secondary or tertiary formations, but rarely, if ever, among primary rocks. The north of Europe and Asia furnishes very little sulphate of lime.

The sulphate of magnesia,—or magnesia combined with sulphuric acid,—known under the name of epsom salts, is found in many mineral waters, particularly all those in the neighborhood of Montpellier. It is also found in a state of efflorescence upon the surface of clay slate, from which it can be easily collected.

§ IV.—Saltpetre and Common Salt.

Nitrate of potassa is composed of potassa, nitric acid, and the water necessary for its crystallization. It is generally known under the name of *saltpetre*, or *nitre*. It is constantly formed in those places, which, like our stables and cellars, contain animal and vegetable matters in a state of putrefaction, or which receive the effluvia of those substances. It is also deposited upon the surface of old walls. As this article is much used in the manufacture of gunpowder, and aquafortis, or nitric acid, they make artificial nitre beds by means of a mixture of vegetable and animal substances.

Chloride of sodium, or common salt, is composed of sodium and chlorine. It is spread throughout nature in an abundance corresponding to its extensive utility. When found in a crystallized state, it is called fossil or rock salt. There are immense masses of it in Poland, in Hungary, in Bohemia, in Austria, in Hanover, in England, in Spain, and generally in all secondary countries. Great quantities of this salt are held in solution by the water of the ocean, as we have already seen. Sea water is sometimes evaporated in shallow ditches, or pits, by the action of the sun, sometimes in large vessels, by the aid of fire, and the salt procured from it has different degrees of strength and sharpness. Some lakes, rivers, and springs contain salt, particularly in the neighborhood of the Caspian Sea, where even the soil is impregnated with it. Salt lakes are generally found near hills of marl, clay, limestone, and gypsum.

§ V.—Salts of Soda, Ammonia, and Alumina.

Borax, or biborate of soda, is of great utility, especially in the melting or soldering of metals. This substance is found as a native production in some lakes and caverns in Thibet, Nepaul, Persia, Tartary, and Saxony; but it is also obtained by a method similar to that used for procuring nitre; and it is also largely manufactured from native boracic acid.

Carbonate of soda is found in certain lakes in Egypt,—in the Lake of Kis-Maria, in Hungary, and in the lakes situated in the plains north of the Caspian Sea. It sometimes covers the plains with a slight efflorescence. It is now manufactured very extensively from common salt and sulphuric acid. Immense quantities of it are used in making soap and glass.

The hydrochlorate of ammonia, commonly called *sal-ammoniac*, occurs in Egypt and Persia. It is also found in small quantities round the volcanoes of Sicily and Italy; and it is made in several

countries of Europe. Mixed with pounded ice, it produces an intense artificial cold.

The salts under consideration seem particularly to abound in plains that are surrounded by mountains; and were formerly the basins of lakes now become dry, or partly run out. The great desert of Sahara appears to be a similar basin covered with saline efflorescence, while the country watered by the Niger is totally free from it. Brazil, in America, is destitute of salt, while Paraguay abounds with it.

Common alum is a compound of sulphuric acid, alumina, and potassa, and is termed in chemistry, the *double sulphate of potassa and alumina*. It is found by itself only in very small quantities; but it is extensively procured from a kind of clay slate containing pyrites or sulphuret of iron.

§ VI.—Alumina and Silica.

Pure alumina, or sesquioxide of aluminum, is distinguished among the elementary earths, by its tendency to mix and unite itself with water. It is found blended with the most dissimilar substances. It is the main constituent of common clay, and of several gems; and it enters largely into the composition of all slaty rocks, granite, basalt, and all the other principal rocks, except limestone, so that next to quartz it may be considered the most abundant mineral which enters into the composition of the earth's crust.

Quartz, silica, or silicic acid—a compound of oxygen and silicon—is by far the most abundant solid substance in nature, so that it has been justly styled the basis of the inorganic kingdom. In most rocks it is the principal, and in some of the primary it is the sole constituent.

When quartz is found in round or angular grains, without cohesion, having a vitreous surface, it is esteemed of no value, being nothing but sand or gravel, and fit to be used only in the formation of roads. If these small grains are united by a natural cement, they form sandstone.

When the same substance has by natural friction been fashioned into small round masses, it is raised into the rank of crystalline flints. When, in consequence of a more regular crystallization, it is of uniform density, and perfectly transparent, it occupies a distinguished place in the collection of amateurs, under the name of *rock crystal*, which is now extensively used in jewelry. This is an abundant substance, and in some parts forms whole rocks.

When of a violet or purple color, the rock crystal becomes *amethyst*, and in this state is highly valued, and classed among gems.

When blue, it is the *sapphire*, which is not so precious. When it assumes the color of rose, it is the *Bohemian ruby*, the most valuable of all. When yellow, it is the *occidental topaz;* when of a green color, it constitutes *prase;* and when of a yellowish brown, it forms *cairngorm*, or *false topaz*. *Chalcedony* quartz is of a bluish gray color, and of an imperfect and cloudy transparency; *cornelian* is only a red chalcedony, of a cherry-like, semi-transparency, and sometimes of a beautiful carnation hue; and the *chrysoprase* is a chalcedony of a delicate and clear green. *Agate* is a chalcedony where the colors are distributed in spots, clouds, or bands. They give the name of *onyx* to agates formed of two translucid stripes of different colors. Oriental agate is distinguished by the fineness of its composition, and the peculiar appearance given to its interior by its various undulated laminæ. The various colors of the preceding gems are owing to the presence of a small quantity of some oxide: for pure quartz is quite transparent. When quartz agate is less fine in its composition, it is used for gun-flints, and for mill-stones.

Opal is a brittle, milky, resinous quartz, with a certain quantity of water. When it exhibits a beautiful play of colors, like those of a rainbow, it is called perfect or precious opal. These vary their shades according to the position. This variety is highly prized on account of this brilliant appearance, which, however, arises solely from minute cracks or fissures, with which it is filled. When divided, it no longer displays this pleasing and changeable effulgence The *hydrophane*, or semi-opal, is one which is not usually transparent but becomes of a beautiful transparency when plunged in water.

Jasper is a quartz agate, blended with alumina and a little iron which gives it a variety of colors. In general, all quartz agates belong to secondary rocks.

The beds of silex, commonly so called, viz.: gun-flints, mill-stones and common flint stones, though inconsiderable in regard to the whole globe, present, in respect to their situation, some remarkable peculiarities. Strata of silex often alternate with those of chalk Hence, some naturalists erroneously thought that they were the petrified remains of marine animals. This rock is entirely absent in Siberia, and is chiefly confined to particular regions.

Quartz abounds in every soil. It is one of the integral parts of most varieties of granite rocks. It also enters, in the form of crystallized grains, into the composition of many rocks of porphyry.

There is scarcely any secondary rock in which we do not find quartz, in masses, in veins, or in crystals.

Arenaceous quartz, or sand, covers almost entirely the bottom of the sea. It is spread over the banks of rivers, and forms vast plains, even at a very considerable elevation above the level of the sea, as the Desert of Sahara, in Africa, and Cobi, in Asia, and many others.

This quartz is produced, at least in part, from the disintegration of the primitive granite rocks. The currents of water carry it along, and when it is in very small, light, and rounded grains, even the wind transports it from one place to another. The hills are thus made to move like the waves, and a deluge of sand frequently inundates the neighboring country. Sand furnishes, by fusion, one of the most useful substances we have, viz.: glass, which being less hard than the crystals of quartz, can be made equally transparent, and is equally serviceable to our wants and pleasures. There, it shines in walls of crystal in the palaces of the great, reflecting the charms of a hundred assembled beauties, in the form of mirrors; here, in the hand of the philosopher, it discovers, in the form of the telescope, the worlds that revolve above us in the immensity of space; and in the kindred form of the microscope, it discloses the no less astonishing wonders that we tread beneath our feet.

We shall now speak of the precious stones which are mainly composed of alumina. The red variety of this class is the true *oriental ruby;* the blue, the *oriental sapphire;* and the yellow, the *oriental topaz.* These valuable and brilliant substances consist of 98 parts of alumina, crystallized, and 2 of iron. Of gems containing both silica and alumina, the most important are the *emerald* and the *beryl*, which differ only in the coloring matter. The principal ingredient is silica, with 16 or 17 per cent. of alumina; from 12 to 15 per cent. of glucina, and some iron.

Garnets contain less silica, and generally more alumina than the preceding, and always a large proportion of lime and iron. The garnets of Bohemia, of a deep, bright red, and those of Syria, of a purple, violet color, sometimes contain one third or two fifths of iron. The oriental garnet is very magnetic. It is a singular circumstance, that such a quantity of iron does not injure transparency. The gems we have just been considering, are found chiefly in the oldest rocks, though they sometimes occur among the secondary rocks.

§ VII.—The Diamond.

The king of gems is the diamond, or used to be considered so; but it is so no longer. Modern chemistry has proved, by multiplied and decisive experiments, that the diamond, far from resisting the fire, like all true gems, is entirely dissipated, without leaving any residuum whatever. Consequently, the diamond is now classed among combustible substances, along with sulphur, amber, and coal. It appears that the diamond consists of pure carbon; and it is now considered to differ from charcoal *only* in being crystallized. Yet it is the *hardest and most brilliant of* all gems; and as it does not take fire

unless heated to redness, its combustibility detracts little from its value. It is generally found in drift, and most abundantly in Hindoston, Borneo, and South America. It has recently been employed for microscope lenses, for which it is very superior to any other substance.

§ VIII.—Felspar.

Felspar is composed principally of silica, with about 20 per cent. of alumina, and a considerable quantity of potassa. Some kinds contain soda and lime. If it be colored, it is by the presence of oxide of iron. It cuts glass, is phosphoric, and emits sparks when struck by steel. Felspar forms the base of many rocks, and predominates in those of a primitive formation, constituting sometimes two thirds of the substance of granite. Extensive mountains are sometimes solely composed of it. Guldensteldt tells us, that felspar, either pure or mixed with granulated quartz, forms the vast plain of rocks which extends from both sides of the cataracts of the Dnieper. The fosses of the fort of Sacharowa, are cut out of natural felspar. It is to this substance that porphyry rocks owe the distinct spots which arise out of their general color; but these rocks rarely present themselves under regular forms. The fine crystals of felspar, whether opaque or colored, or limpid and transparent, occur in primary rocks; and the Lombard Alps have mostly furnished what the cabinets of France consider the most perfect specimens of this kind. But the most beautiful crystals of felspar, which join to a fine green color a great degree of transparency, are found in detached blocks, or masses, in the steppes of the Kirguis, whence the Bucharians carry them to Semipalatnoi. The mountains of Siberia, towards the Lake Baikal, have supplied those large plates of azure felspar, with which the palace of Czarskoselo is adorned. It appears, then, that this substance abounds still more in the Alps of Asia, than in those of Europe. On the contrary, America does not appear to afford it in large quantities.

Felspar, even when decomposed, still maintains a character of importance. It is found in extensive beds, from the Uralian Mountains to Kamschatka. Of the two substances which the Chinese use in making porcelain—the one named petunz, is a whitish, laminated felspar; the other, called kaolin, is a clayey felspar, that is, felspar that has passed by decomposition, from the state of a stone to that of a very brittle clay, without cohesion,—combining with water,—of a fine white color, and infusible by itself, the petunz acting as a flux. The same substances are employed in Europe in the manufacture of porcelain ware.

§ IX.—Mica.

Mica, a substance remarkable for its metallic brilliancy, is distinguished from talc, by its pure, smooth surface, and by not being like talc, unctuous to the touch. The variety of mica which consists of large, thin, transparent laminæ, is mistermed talc of Muscovy. It is called Muscovy glass, in consequence of the Russians, especially in Siberia, using it in their windows instead of glass; but it soon becomes soiled, and, in some measure, loses its transparency, by exposure to the air. Another variety of mica, in spangles of a yellow gold, or whitish silver color, is known by the ridiculous name of cat's gold, or cat's silver. The gilt sand, and gold powder which the paper-makers use for purposes of ornament, are only mica in small fragments.

Mica is found chiefly in the older rocks; that which is imbedded in more recent formations having been conveyed thither after the destruction of the rocks which enclosed it. This took place the more easily, as its particles, thin and light, were susceptible of being carried along by the waters, which deposited them with other sediments of an analogous nature. The remains of mica are also found in the beds of hard graystone, and clay slate, which generally alternate with strata of coal. Its fragments are still disseminated in the sands of the most recent epoch; thus it exists in different states, in substances of every formation. It appears that in the south of Europe, mica is rarely found crystallized, by itself; that in rocks, it does not form laminæ of any sensible extent, and that even in the state of veins, its plates are only some inches in dimensions; but all agree in asserting that it is found in Russia and Siberia, in laminated masses, sometimes more than two yards square. It is found in detached masses, and it sometimes appears on the surface of the earth, but is oftener covered with a bed of talc. Near the Lake Baikal, and in the Uralian Mountains, we meet with masses composed of rhomboidal and hexagonal laminæ of transparent mica, in the midst of granite, of which rock it forms a constituent element. Mica generally consists of silica, alumina, oxide of iron, and potassa; but different specimens differ not a little in their composition, as is the case with many other minerals.

§ X.—Talc, Hornblende, Serpentine, &c.

Talc, which differs from mica by the greasiness of its surface, is also less hard, and is easily scraped with a knife. On the other hand, it differs from soapy clay, because it forms no paste with water,

and does not adhere to the tongue. The talc of Venice, which abounds in the Tyrol, and Valteline, is of a greenish white, silvery, and divisible into thin, transparent, and flexible plates. It furnishes a powder, which renders the skin smooth, and is employed as a cosmetic. The scaly talc, is known as chalk of Briancon. Steatite, or rock soap, is the graphic talc of Haüy. This is the substance of which those little figures are made, which are brought from China, and whose grotesque appearance has caused them to be called magots, in allusion to a species of monkey, which bears that name. Talc consists mainly of silica and magnesia.

This substance belongs equally to the primitive and secondary rocks, but is less common in the latter. The purest talc is found in detached nodules, imbedded in micaceous rocks; but it occurs occasionally in granite, and in limestone.

Hornblende, otherwise called *amphibole*, is a dark, greenish rock, composed of silica, alumina, iron, lime, and magnesia. It is frequently translucent at the edges; and this, with its color, suggested its name. This substance sometimes forms whole rocks; it is always the predominant ingredient in hornblende slate, and it occurs with felspar and quartz in some granites, in syenite, greenstone, basalt, and lava. *Augite* is nothing but a slight modification of hornblende, and is identical with it in composition, as well as in general appearance. It occurs chiefly in basalt and lava. Felspar, and either hornblende or augite, are the predominant and characteristic minerals in all the unstratified rocks. In granites, porphyries, and trachyte, felspar predominates, while hornblende or augite is more abundant in basaltic rocks. In syenite and greenstone, the two kinds are nearly equal.

Hypersthene resembles hornblende, but it is of a darker color. In composition, it contains much less alumina, and lime, with much more magnesia, and also more iron. It occurs with felspar, in hypersthene rock, and in the granites, syenites, and greenstones, which are distinguished by the epithet, hypersthenic.

Serpentine is a rock so named from its greenish, mottled appearance. It contains silica, an extraordinary quantity of magnesia, and lime, with some iron. It occurs in immense quantities in the United States. It is somewhat unctuous to the touch, and of a translucent appearance. It occurs alone, and intermixed with primary limestone, constituting the beautiful marble called *verde antique*.

§ XI.—Asbestos.

This substance is also called amianthus, and is chiefly found among primary rocks. It occupies fissures and cavities of steatic

rocks, serpentine rocks, and others abounding in magnesia. The asbestos which is found in the mountains of Tarantaise, in Savoy, forms silky filaments of more than a foot in length. When people see for the first time a detached tuft of asbestos, they can scarcely be convinced that it is actually a stone, and not a species of fine white silk. Asbestos abounds in Corsica. Dolomieu made use of it, instead of hay and tow, to pack up other minerals. Crampini says, the longest asbestos he ever saw came from the Pyrenees. It abounds in the Uralian Mountains, and in Greenland. In Corsica, they mix asbestos with the clay used in the potteries; which is thus rendered less brittle and more capable of resisting the sudden alterations of heat and cold. The ancients spun the asbestos, and made towels, napkins, and head-dresses of it. When these became soiled by use they were thrown into the fire, which did not destroy the substance of the asbestos; and, upon being taken out, these articles of domestic use were found to be whiter than if they had been washed. In the funeral obsequies of kings and emperors, the dead body was enveloped in cloths of asbestos before it was placed on the funeral pile, and thus the ashes were obtained quite unmixed. In modern times, the Russians alone have attempted, but without success, to spin the asbestos. The inhabitants of the Uralian Mountains have still preserved some remains of this frivolous industry. The indestructible paper made from this substance appears more useful for preserving valuable records from the ravages of fire. Wicks for lamps are also formed of it, which easily imbibe oil, and burn with a brilliant flame. Father Kircher made use of such a wick for more than two years, without any perceptible decay; but having wet it by accident, he was prevented from continuing his experiment. Perhaps the fabulous accounts of unextinguishable sepulchral lamps derive their origin from this circumstance. It is hornblende, without any alumina, and with a greater proportion of iron.

§ XII.—Sulphur and Carbon.

The sulphur which is crystallized by the action of a liquid is found in veins or in beds, amongst sulphate of lime, or amongst potters' clay. These beds, which are often very extensive, border upon strata of rock-salt. Crystals of sulphur sometimes adorn the interior of calcareous, or even quartz, geodes, or eagle stones. With respect to sulphur formed by sublimation, it is found in powder in striated masses, or even in crystals, at the mouth of many volcanoes, such as Etna, Vesuvius, and Mount Hecla. Sulphur is often obtained from the putrefaction of animal matter. Several substances, among others the sulphurous pyrites, are impregnated with sulphur. We cannot doubt that sulphuric and sulphurous acid exerted a

powerful agency during the primitive action of the elements; but there is little in the existing economy of nature which can enable us to penetrate these mysteries of "chaos and ancient night."

Of carbon there are few traces found in the primitive rocks; it occurs mainly in those of more recent origin. It seems to have been ejected from volcanoes, probably united with oxygen. We have already mentioned the diamond as a specimen of pure crystallized carbon; and although that gem is proverbially rare, its substance is so common that carbon is considered the basis of organic nature, as silica is of the inorganic. It is an essential element in all animal and vegetable tissues, and occurs so abundantly in some formations, that they are styled carbonaceous.

§ XIII.—Bitumen.

This is one of the many substances which consist mainly of carbon. When in a liquid state, it is of a brownish color, and commonly bears the name of *petroleum*, or *mineral tar*, and when it is white and transparent, that of *naphtha*. It filters through the earth and rocks, which remain impregnated with it. The springs of it, at Baku, in Persia, are well known.

It floats sometimes like oil upon the surface of the waters. It is said that there is a lake of this description in Mesopotamia. In the duchy of Parma, it is drawn up in buckets from wells sunk in the earth for the purpose. The same substance, in drying, passes to a state of glutinous bitumen, named mætha, and mineral pitch. When it becomes solid, it is called *asphaltum*, and gives its name to Lake Asphaltites; or the Dead Sea, in Palestine. It appears that a subterraneous fermentation detaches from a bed of solid bitumen, situated under the lake, those crusts of asphaltum that are seen swimming on the surface of the water. Glutinous bitumen is found in France, at a place called Puy de La Pège, where it covers the earth, and sticks to the feet so as to incommode and retard the traveller. In Persia, Japan, and other countries, they use liquid bitumen as oil for their lamps. The Persians and Turks mix it with their varnish, to give it lustre. The walls of Babylon were built with a cement in which bitumen formed an ingredient. Rouille has concluded, from his experiments upon mummies, that the Egyptians employed bitumen in their embalming.

§ XIV.—Coal.

Coal, and all other bituminous substances, are only decayed *vegetable matter*, sometimes mixed with earthy and animal substances.

This origin is indicated by the impression of different plants, particularly the fern tribe, in the slaty clays, which form the roofs of coal mines; and by wood, still partly in a ligneous state, and partly bituminated; so that we can, from such appearances, trace the process followed in the formation of coal, from one point in the scale to the other. The microscope detects vegetable structure in the most perfect coal; and chemical analysis proves that it gives the same products as woody tissue, viz.: carbon and the elements of water. But the former is in excess. Hence, coal is vegetable matter deprived of part of its water by heat, and consolidated by pressure.

Coal is most commonly found in France, and in England, where the primitive and secondary rocks join; whence it has been concluded that beds of coal were collections of substances deposited by the ancient sea, along the shores of the ancient earth. It is supposed that the rivers would bear along trees, plants, and bodies of animals toward the sea, which would throw them back upon its primitive shores, where they would accumulate in beds and masses, and in that condition enter into a state of decomposition and combustion. The mines of coal ought, then, to be found on the recently elevated lands of the new, or actually existing earth, around the islands of the primeval ocean. Such is, amongst others, the disposition of the coal mines around the Hartz Mountains, as described by Lehmann. But the simplicity of this theory does not account for the complicated circumstances connected with the position of coal. The numerous beds of sandstone, of clay slate, and chalk, which generally separate those of coal, show us that this last substance has been formed at different intervals, in a fluid, and perhaps, in part, at a period when the present vegetables and animals did not exist. The intermediate beds which separate the strata of coal, frequently preserve with these strata a constant parallelism. This is the more remarkable, as there are beds of coal which are scarcely an inch in thickness, although often several leagues in extent. It has been concluded, and with sufficient probability, that these beds were formed in interior lakes, and consolidated in calm waters. It must, at the same time, be stated, that we observe other beds of coal, which indicate circumstances of great confusion. Near Valenciennes, some beds which are vertical, or almost vertical, are covered over by an alternate superposition, with beds parallel to the horizon.

The great extent of beds of coal, presents another subject worthy of consideration. They appear to pass under the very bottom of the sea. In the Danish Island of Bornholm, which is composed of a secondary formation of calcareous and clayey earths, we find a considerable bed of coal, which comes from the Baltic Sea, passes under the island, and extends itself again under the sea, towards the opposite coasts of Scania, a province of Sweden. This bed, the thickness

of which is not known, may be from five to seven leagues in length, and more than one league in breadth. We may conclude, according to the apparent direction of the bed, that it ought equally to extend under the secondary clay rocks in Scania; and in fact, a bed of coal has recently been discovered upon the borders of the sound, at the entrance of the Baltic, which is probably a continuation of that in Bornholm.

It is a very remarkable thing, that coal, a substance so easily inflammable, is found covered over with substances, which, if they are not the products of volcanoes, seem at least to owe their origin to fusion, occasioned by the powerful action of caloric. The Islands of Faroe, which appear to be nothing but masses of basalt, and which rise perpendicularly from the bosom of the sea, to the height of 1,800 feet, contain an extensive mine of coal, inclining to the variety named dry coal. According to the descriptions given of it, it seems, at once, to have for its wall, its roof, and its support, basalt, or other trapp rock.

Anthracite coal differs from bituminous coal, only in being deprived of nearly all its water, and being intermixed with silicious matter, which renders it more difficult to burn. Coal is found chiefly in the lower fossiliferous rocks. No coal is ever found in primary rocks, and valuable beds are very seldom found above the red sandstone.

§ XV.—Amber.

Amber abounds in the Asturias, in beds of coal, and in Eastern Prussia, where the Baltic Sea throws pieces of it upon the coasts, and where, formerly, the fishermen collected lumps of it in their nets; but now most of it is procured from the hills of sand in the neighborhood of the sea. The largest piece of amber ever known, weighs 13½lbs., and is preserved in the royal museum of Berlin. Next to Prussia, Eastern Pomerania furnishes the greatest quantity of amber, where it is worked in quarries. In general, the whole of the plain which borders the Baltic Sea on the south, produces amber, commonly within the beds of sand and clay, sometimes in the midst of imperfect coal. These deposits of amber extend from Livonia, and particularly from Courland to the western coasts of Sleswick, where, perhaps, the Phenicians purchased this substance, formerly so much sought after.

The situations in which amber occurs; the physical and chemical qualities of this substance, which appears to approach the resinous gums; the insects which are found enclosed within it, as in a crystal prison; everything, in short, connected with its history, would induce us to regard this fossil as a juice which once flowed from a tree, and

which, buried in the earth by some natural convulsion, would be impregnated with mineral vapors, and acquire a certain degree of consistency. But as the copal, the only kind of known gum which resembles amber, is brought to us from Africa and the East Indies, it would appear, that the forests in which amber is produced, could not exist in the environs of the Baltic, unless a very elevated temperature prevailed. Thus these small fragile crystals, which at first seem to be only an object of idle curiosity, become so many monuments of the revolutions which our planet has experienced.

§ XVI.—Metals.

Metals, from their brightness, weight, density, ductility, and fusibility, have long engaged the attention of the mineralogist and crystallographer. These substances, which form sometimes the representative signs of the products of industry, and sometimes the useful or the formidable instruments of the arts and passions, ought to be carefully noticed in the description of political states; but they peculiarly deserve attention in the details of physical geography, from the intimate relation which they bear to the two great agents of nature, electricity and magnetism.

Physical geography indispensably requires that a subject of this nature should constitute one of its departments; and, if we devote to it a certain portion of our pages, our readers will perceive in the progress of the work, the advantages which are thus afforded, even in the study of political geography.

§ XVII.—Platinum.

Platinum remained unknown, or neglected, until 1735, when Don Ulloa, a Spanish mathematician, who accompanied Condamine and Bouguer in their voyage to measure a degree of the meridian, in Peru, having found this metal there, announced the discovery of it in the relation of his voyage. Platinum was formerly found chiefly in the mines of South America; but rich mines of it are now worked in the Ural Mountains. It is the least fusible of all the metals. In order to melt it into ingots, it is mixed with arsenic, a substance which renders it very fusible, and from which it is afterwards easily separated, by roasting, although this process exposes the workmen to vapors, the danger of which is, unfortunately, but too well known. It is of platinum that those rods are made, that have been employed in measuring the base of the chain of triangles, whence has been deduced the length of the arc of the meridian which traverses France;

and, by consequence, the distance from the equator to the Northern Pole. This metal was chosen for such purposes, because it has little susceptibility for dilating, or contracting, from the variations of temperature. Its dilation, according to Borda, is only $\frac{1}{116000}$ for one degree of the centigrade thermometer, whilst a rod of iron dilates $\frac{1}{81750}$ for a centesimal degree.

Platinum is now very extensively used in the arts, and upon the whole, may be considered more useful than gold, to which it is quite equal in resisting the action of acids.

§ XVIII.—Gold.

Gold is chiefly found in its native state, that is, almost pure and unmixed. It exists in all kinds of earth. It is found in little beds, in the primitive mountains of gneiss, and of micaceous clay slate, in the country of Salzburg, and in Carniola; it occcupies veins in the mountains of syenite and porphyry, near Kremnitz, in Hungary; in the secondary rocks of argillaceous quartz, or even of sandstone, at Zalatna, in Transylvania; and in an argillaceous freestone, not far from Ekaterinburg, in Siberia.

Europe produces comparatively little gold, the only mines of any consequence being those of Hungary and Eastern Russia. Since the discovery of America, the principal supplies have been drawn from that quarter. In going from La Paz, towards Potosi, and Tucumano, all the beds of clayey slate are found penetrated with veins of auriferous quartz; and the fall of a shelf or rock, discovers masses of gold, from 200 to 300 lbs. in weight. The islands of Borneo, Celebes, or Macassar, and of Sumatra, situated under the equator, contain very rich mines of gold, though badly worked. Rich gold mines were discovered in the Ural Mountains, about 25 years ago. The most productive are on the Asiatic side. And a great part of the civilized world was very lately excited by intelligence of extremely rich gold mines in California. But, although this country will probably produce much gold in the aggregate within the next 50 years, it has not yet produced an annual amount equal to the Siberian mines, and to all appearances never will. In Africa, gold has been found chiefly in auriferous sands along the rivers. In Nigritia, the natives are regularly employed every year in this golden harvest, after having finished that of the corn. Near Akim, on the coast of Guinea, it is said one person may pick up several ounces per day. But this statement is contradicted by other accounts. Gold, like diamonds, is found chiefly in drift. The recent discoveries explode the notion that gold is found chiefly in the equinoctial regions.

The valuable qualities of gold render it worthy of the rank which

opinion has assigned to it among metals. Though less brilliant, and much more fusible, than platinum, it has a color more agreeable to the eye. Thus, the poets have not failed to give golden locks to Apollo; to Jupiter a throne of gold; Vulcan employs gold to forge a buckler for Achilles; in short, in the form of an adjective, the words gold and beauty, are synonymous amongst the Greeks.

From its great ductility, gold assumes every form we wish it to acquire. The goldsmith, the jeweller, the embroiderer, the gilder, employ it with equal facility. It is capable of the most astonishing superficial extension, thus making up, by its ductility, for its scarceness. A quantity of gold of the weight of one grain, can be beaten out into a sheet, the surface of which will cover 50 square inches, and when used in the gilding of silver wire, its extension is nearly sixteen times greater. The tenacity of gold is very remarkable, though inferior to that of iron. Haüy says, that one thread of gold, of $2\frac{7}{10}$ millimetres, or $\frac{1}{10}$ of an inch, in diameter, can support a weight of 244 kilogrammes, or 500 lbs. As gold is very soft, it is mixed with copper when coined into money, to give it hardness. Much of its value arises from its being entirely unaffected by air or water, or any simple acid.

§ XIX.—Silver.

Native silver is frequently found pure in the bosom of the earth; it is also found mixed with copper, gold, arsenic, and sulphur. The same province of South America, which contains the richest gold mines, viz., Peru, contains also great treasures of silver. The mines of Potosi produced, from the year 1545 to 1770, about $1,648,000,000, and a small part of them only has yet been excavated. In North America, Mexico abounds in silver, about $22,000,000 being derived from it every year. Silver is apparently diffused throughout the whole extent of the old continent; but the mines that are now best known, are almost all found in the north temperate zone. Those of Siberia, of Saxony, and of the Hartz, are at the 50° of lat.; those of Konigsberg, in Norway, at the 60°. The very productive mines of America, are contained within the two parallels distant 30° from the equator. We are ignorant, whether Africa possesses mines of silver equal to those of the New World.

Silver is found chiefly in the primary and transition rocks. At Frankenberg, in Hesse, leaves of native silver are found adhering to petrifications. A mass of silver was found at Konigsberg, weighing upwards of 600 pounds. It is preserved in the Royal Museum, at Copenhagen.

Silver is, next to gold and platinum, the most unalterable of the

metals. It is remarkable that silver, alloyed with a considerable portion of gold, or copper, preserves its whiteness, while a small quantity of silver, or copper, mixed with gold, changes very sensibly the color of this metal. When dissolved in nitric acid, silver crystallizes under a kind of vegetable or arborescent form, producing what is called the *tree of Diana*. It would seem, that the crystals of which this kind of mineral vegetation is composed, may be considered as small magnetic rods, whose poles, by attracting and repelling one another, determine their respective positions.

Silver, though less rare than gold, has been preferred to that metal as a representative of value. The resistances which it opposes to the action of the air, and humidity, its brilliant whiteness, and its malleability, render it applicable to a multiplicity of purposes, ornamental and useful, which are too well known to require enumeration.

§ XX.—Mercury.

Native mercury is generally found in brilliant and movable globules, disseminated in the clayey slate, as at Idria, in Carniola; in marl; in quartz, as in the district of Deux Ponts; and in primitive limestone, as at Almaden, in Spain. This metal requires so little heat for its fusion, that the atmosphere generally contains enough to preserve it in the fluid state. The cold of northern regions, however, converts it into the solid form, which has been erroneously considered as congelation. It is then almost as malleable as tin, and admits of being expanded into very thin sheets. Mercury amalgamates with almost all metallic substances, but chiefly with gold, silver, tin, and bismuth. It is this property, joined to the facility with which it evaporates, that causes it to be employed in gilding, and in working mines of gold and silver. The silvering of glass is effected by the amalgam of mercury and tin. Its extensive use in medicine and in the construction of barometers and thermometers, renders it an object of great importance in science. The principal supplies of it are procured from the places just mentioned; but many valuable mines exist in America, although hitherto they have not been extensively wrought.

§ XXI.—Lead.

Lead is a substance of very dense structure, but extremely deficient in point of hardness, elasticity, and even ductility. It is, however, of great utility in its metallic state: conduit pipes, musket

balls, small shot, and many plain and coarse instruments are made of it; and its oxides are employed in many of the arts. It is also employed in the manufacture of glass, which it renders susceptible of being easily cut and polished. It is to its red oxide that flint glass owes the quality which renders it so valuable in the construction of the object glasses of achromatic telescopes, viz., that of divesting the images of those colors with which they appear to be edged when we view them through a common telescope. The oxides of lead furnish a variety of colors, both to the pallet of the painter, and the toilet of the modern belle, though to the latter it sometimes proves a treacherous aid.

This metal is generally found mineralized by sulphur, forming an ore commonly called galena, which is almost always mixed with iron, with antimony, and especially with silver. This ore is often worked only for the purpose of extracting from it the silver it contains. Werner specifies 17 formations of galena of different periods, in all sorts of rocks, from the quartz to pit coal. There are no mines more common in Europe. The kind of galena which contains silver is met with in Lapland.

Lead is not found in abundance anywhere in the north of Europe or Asia. It begins to discover itself in great quantities in Germany, France, and England. Very extensive mines are found in Missouri, Iowa, and Wisconsin, which are now actively wrought.

§ XXII.—Copper.

Copper, one of the metals of which nature is most lavish, appears to occupy two great regions of the globe, which admit of being distinctly defined. We know that it abounds in Norway, in Sweden, in Hungary, in England, and in the Uralian Mountains; throughout all Siberia, in Chinese Tartary, and Japan. We must also add that several islands between Kamschatka and America, produce masses of native copper. Immense beds of it are found upon the sides of the Ohio, and all around the great lakes; and there have ·· n signs of its existence in Greenland, and in Iceland. This al seems to be common to all the countries situated in a zone ıbout 45 degrees of latitude around the North Pole. But it is ..d on the other side, all over the south of Africa from Congo to the Cape of Good Hope, and, according to Benyowski, in Madagascar. South America also contains extensive mines of it. In Brazil, they are abundant, and still more so in Chili. And as it is found extensively in Morocco, in the Island of Cyprus, and in Turkish Armenia, we may regard it as a substance common to all the zones of our planet.

With respect to native copper, mineralogists agree in distinguishing two different formations. Copper of the first formation is in crystals, thin plates, threads, or clusters, which are commonly found attached to quartz, or clay slate, and sometimes primitive limestone. The other kind is of more recent formation; it is obtained from sulphate of copper, or blue vitriol, held in solution in water, and decomposed by the application of heat. It forms concretions upon different stony substances, and even upon organic bodies. In the mines of Kopparberg, in Sweden, of Rœras, in Norway, in those of Siberia, and in general in all the great copper works, this mineral is usually obtained from pyrites of a yellow or iris color, in which it is found mineralized by iron and sulphur. The gray-colored copper contains silver, antimony, lead, sulphur, &c. The sulphuret of copper, or copper combined with sulphur, has a vitreous appearance. In the state of oxide, copper assumes various tints, red, blue, or green. The silky or pearly carbonate of copper presents a green color like an emerald, softened by a kind of satin lustre which gives it a more beautiful appearance.

Copper, in a state of concretion, forms the substance called *malachite*, which is susceptible of a fine polish, and of which the surfaces of mantel-pieces, snuff-boxes, and various trinkets are made. Haüy calls it the alabaster of metallic substances.

Copper is much more ductile than iron, and more durable than tin or lead. Its tenacity is such that one wire of copper $\frac{1}{10}$ of an inch in diameter can sustain, without breaking, a weight of 320 lbs. The useful qualities of copper are partly balanced by its very changeable nature. Exposed to the air or the damp, it is very soon covered with that rust which is one of the most active of poisons. When melted and refined, it is called *rose*, or *purified copper*, which is less dense than native copper. *Brass* is a compound of copper and zinc. Being less subject to rust than copper, it furnishes the mechanical philosopher, the watch-maker, and the geometrician, with many instruments of general use, exquisitely delicate in their workmanship, and at the same time of great durability.

The best brass contains four parts of copper to one of zinc. If the mixture contains a greater proportion of zinc, it takes the name of *pinchbeck*, *tombac*, and *gold of Manheim*.

Bronze, or *gun metal*, is made by uniting with copper a certain portion of tin, generally about 10 per cent. This is the brass mentioned in ancient authors. It is more sonorous than pure copper, and differs from *bell metal* only in containing less tin. This last is used for making the specula of reflecting telescopes, as well as for bells, and hence it is called *speculum metal*.

Bronze has been employed for statues from the earliest times; and it is at present extensively employed in making brass cannon.

§ XXIII.—Tin.

Tin is a mineral found chiefly in the oldest formations of granite, porphyry, and gneiss, in the form of a deutoxide.

This metal is found in Cornwall in England, in Saxony, and in Bohemia; it is scarcely ever met with in other parts of Europe. It entirely disappears when we penetrate into the interior of the ancient continent, and does not again discover itself till we reach the Peninsula of India, on this side of the Ganges, whence its mines extend to the Peninsula of Malacca, and to the islands of Sumatra, Banca, and Japan. Africa and South America produce little of it.

The tin which is used in the arts for coating glass, for solder, for cooking utensils, and for the composition of scarlet, possesses the singular property of rendering more hard and more sonorous the metal with which it is mixed, although by itself it is deficient in these two qualities. At the same time, it takes away ductility from metals possessing that quality in a high degree, while it does not diminish the ductility of the less ductile metals.

§ XXIV.—Iron.

Iron is at once the most useful, the most abundant, and the most widely distributed of all metals. It is found in abundance in almost every part of the world. Its importance is such that most of the comforts of life, and many of the arts and sciences, are dependent on it. It enters, either as a coloring, or a combining principle, into a great number of mineral substances. It is a stranger, neither to vegetables, whose tints it enlivens, nor to animals, upon which it exerts a salutary influence.

An immense quantity of iron is contained in the mountains of Scandinavia alone. The Mountain of Taberg, in the south of Sweden, presents only one entire mass of mineral. It is also abundant in Britain. The north of Asia equally abounds in iron. Canada contains excellent iron, though copper appears to predominate there. The western states abound with the finest kind of iron. The mines of Missouri are among the richest in the world, the Iron Mountain of that state being composed entirely of specular iron ore. Southern Africa abounds in this metal. No kind of rock or earth is a stranger to it, and the red color of most soils is owing to the presence of its oxides. It is found in granite, in detached masses; in clay slate, in a thread-like form; in sandstone, in beds. It exists very extensively even in mud and turf. Hence, we cannot but admire the bounty of Providence, in distributing everywhere so abund-

antly a metal of much more importance than all others taken together.

The great masses of native iron found in Siberia, and in America, were formerly considered as productions of art, or of volcanic agents; but now they are thought to have an ultra-terrene origin, and to have been attracted by the earth in their motions through space, perhaps round the sun. Iron is generally found in aerolites, which are now universally allowed to have such an origin. Native iron is also found in mines; but this is a rare occurrence.

One of the most valuable ores of this metal is the black or magnetic oxide, to a variety of which the name *loadstone* has been given.

The peroxide, or specular ore of iron, abounds in Sweden and Norway, in the Isle of Elba, in some parts of France, and in the United States. It is most easy to work of all the ores of iron.

Sparry iron ore is only a carbonate of lime, more or less mixed with iron. The lime with which the ore is combined facilitates the fusion. The iron which is drawn from it is of an excellent quality, and it has a great tendency to pass into steel, even in the first fusion. This is what is called *steel ore.*

Sulphuret of iron, which is commonly called *iron pyrites*, is one of the most remarkable substances which enter into the composition of the globe. It is very extensively distributed, being found in quartz, in marl, in the argillaceous slate which lies upon coal, and even mixed with coal itself. In the greatest depths to which man has ever been able to penetrate, in the most considerable mines, we continue to observe the iron pyrites, until our progress is arrested by the subterraneous waters.

There is auriferous pyrites, which, although chiefly consisting of decomposed sulphuret of iron, is worked like ore of gold, and with the view of extracting from it this last metal.

Green vitriol, or sulphate of iron, is of great service in dyeing; it is used as the principle of black color, from the property which gall-nuts and other astringent vegetables possess of precipitating iron, contained in the vitriol, under the form of black particles of extreme fineness.

Iron is very different as nature produces it, from that whose appearance and use are so familiar to us. It is generally nothing but an earthy mass, an impure and dirty rust; and even when it presents itself to us in the mine, with metallic brightness, it is still very far from possessing the qualities required for the multiplicity of uses to which it may be applied. *Pig cast* iron, is the metal after its first fusion, deprived of a more or less considerable portion of its oxygen, and combined with a part of the carbon with which it came in contact, in the casting furnace. Cast iron is not yet rendered sufficiently malleable or ductile. To render it so, it is again submitted

to the action of the furnace, the elevated temperature of which determines, by a new exertion of affinities, the oxygen remaining in the cast iron to combine with the carbon, which had been incorporated with the iron, and thus to form carbonic acid, which constantly disengages itself from the mass. Iron, after this process, is found in a sufficient state of purity to answer all ordinary purposes. It is then exposed to the action of a large hammer, whose redoubled strokes, by bringing the metallic particles into closer contact, unite them more perfectly together, and render the iron sufficiently malleable and ductile. It is then called *forged iron*. In this new state, it is no longer fusible by the heat of an ordinary furnace: and before becoming liquid, it passes through a soft, pasty condition. Forged iron is now placed in contact with carbonaceous substances, and again softened by the action of fire; and the moment it enters into combination with these substances, or rather with the carbon they contain, it becomes steel, which is a carburet of iron.

The operation of tempering, which steel undergoes, does not change its nature—it only varies the arrangement and aggregation of its particles—it augments at once its hardness, its brittleness, and its volume, and gives it a coarser grain than that of steel not tempered. Thus, the difference between cast iron, forged iron, and steel, depends mainly on two principles, viz.: oxygen and carbon. The union of these two principles constitutes cast iron; the absence of both, at least in a perceptible quantity, characterizes forged iron; and in steel, carbon exists alone, without oxygen.

§ XXV.—Qualities of Iron.

The tenacity of iron is such, that when drawn into a wire of $\frac{1}{50}$ of an inch in thickness, it can support, without breaking, a weight of 60 lbs. Iron is very oxidable, and it exerts a very strong elective affinity towards sulphur. United with silica and alumina, it imparts an extreme hardness to rocks which contain it. There is no metal which allows itself to be so easily decomposed, and no metal forms a more unalterable cement. Its magnetic virtue readily communicates itself to other metals with which it is mixed; $\frac{4}{100}$ of iron make copper magnetic; $\frac{5}{100}$ have the same effect upon tin. These physical qualities prove what an important part it must have acted, in the formation of those aggregate substances which compose our globe.

§ XXVI.—Zinc, Antimony, and Arsenic.

Zinc, which forms the connecting link between the ductile metals, and those which are not so, is found oxidated, and then it is commonly called calamine, or *lapis calaminaris*. There are mines of it in France, Austria, England, and several of the United States. Calamine is seldom found in primary rocks. The most important ore is the sulphuret, which is found chiefly in the older rocks, and goes by the name of *blende*. This mineral is scattered over Sweden, Norway, Saxony, and Bohemia, and we may almost say, everywhere. It generally accompanies sulphuret of lead. It is often mixed with iron, gold, and silver. The sulphate of zinc, which is rarely a product of nature, is called *white vitriol*. The metal which is brought from India, under the name of *tutenag*, is, according to Bergmann, zinc, in a state of purity. If the air be admitted to zinc, when brought almost to a white heat, the metal burns with a splendor that nothing can equal, and which is too dazzling for the eye to support. This property serves to characterize zinc, not only amongst the metals, but even among combustible minerals.

Antimony, once celebrated in the laboratories of the alchemists, who hoped to discover in it the philosopher's stone, is now employed with success in the composition of many medicines, and as an alloy with lead in the casting of types for printing. Alloyed with tin and a little copper and bismuth, it forms that fine kind of pewter termed *prince's metal*. It is found native in quartz, and primitive limestone. The most common ore is the sulphuret, which is found chiefly in granite, gneiss, and mica slate. It is often united with galena, and goes by the name of *gray* antimony.

Arsenic, the name alone of which excites an emotion of terror, is not often found by itself; but it serves to mineralize a great number of metals. It is generally associated with silver or copper. Rubbed, or warmed, it discovers itself by the smell of garlic which it emits. Its native metallic color is of a steel gray. That which is met with around volcanoes, is mineralized by sulphur. Metallic arsenic is not poisonous. This property belongs to *arsenious acid*, a white powder composed of arsenic and oxygen. This is often termed, by way of distinction, *white arsenic*.

§ XXVII.—Granite and Syenite.

Having sufficiently discussed the simpler elements of rocks, we shall now briefly consider the principal compounds of these, which constitute the great mass of all known rocks.

Granite is the oldest and most crystalline of all rocks. It is generally composed of quartz, felspar, and mica. The latter is sometimes wanting; while some varieties contain hornblende. Where the latter supersedes mica, the compound is termed *syenite*, from Syene, in Upper Egypt; although the rocks of that place are in reality pure granite. Mount Sinai, however, consists of this kind of rock, and hence the term *sinaïte* would be more proper. The agreeable variety of colors which the felspar reflects, the lustre of the mica, the whiteness of the quartz, the sombre green of the hornblende, especially when polishing has developed their natural shades, often impart to granite a most magnificent appearance.

The variety which contains no mica is termed *graphic* granite, because the quartz is disposed in broken lines, so as to suggest the idea of Runic, or Hebrew characters. Granite is not only the most ancient of the rocks, but it appears to constitute the base of all others. It is supposed to underlie the stratified rocks throughout the whole world; and it is not improbable, that it forms an immense vault around the globe. We know that granite is everywhere found beneath the other rocks; and that, of the highest mountains in the principal chains of the world, it is granite that constitutes the foundations and the mass. The crystallization which has united the substances of granite, must have occasionally met with one or the other in excess, producing the varieties already mentioned.

§ XXVIII.—Quartzeous Rocks.

These are rarely found pure. There appears, however, to have been a very peculiar formation of pure quartz. Strong veins of it are seen traversing the granite mountains; and the vast wall of quartz, upon the Mountain of Felsberg, near Manheim, excites the wonder of the naturalist. The rock which most nearly resembles the granite, unites to the granulated structure of the latter, an arrangement of parts which gives it a foliated appearance;—the quartz and felspar are found there in grains; but the mica forms bands, or very thin layers.

§ XXIX.—Porphyry.

The porphyries, properly so called, are masses of imbedded felspar, colored by a metallic oxide, and containing crystals of the same kind. Such is the superb red, antique porphyry, originally from Egypt, and of which only imperfect varieties are found in Europe. Such are still the *ophites, or serpentine* antique porphyry, although checkered with

plates of hornblende, a substance which abounds more and more in black porphyries. All rocks with a homogeneous earthy base, containing crystals of another substance, and of contemporaneous origin, are now denominated *porphyries;* and that of which we have spoken is distinguished as *felspar* porphyry: but when porphyry is spoken of in general terms, this kind alone is meant.

The disorder, or rather, capricious order, according to which the particles of the porphyries have crystallized, sometimes occasions the most brilliant and fantastical appearances. Who would not admire the orbicular porphyry of Corsica, which, on being polished, displays circles composed of little yellowish red leaves, arranged in rays, around a reddish brown kernel; and which presents to the eye a transverse section of some unknown and delicious fruit?

§ XXX.—Trapp Rocks.

These are composed principally of felspar and hornblende, or augite. They are named from the Swedish *trappa*, a stair, as they are often arranged in the form of stairs or steps. They are all of more recent origin than granite, and less crystalline. The columnar arrangement of the basalts belongs to this class, which includes a great variety, the principal being greenstone, basalt, clinkstone, compact felspar, pitchstone, amygdaloid, trapp and pitchstone porphyry, and amygdaloid rock. They are all of igneous origin, and destitute of any indications of stratification.

The amygdaloids are rocks which derive their name from their similarity to almonds, imbedded in paste, and may be composed of any paste whatever, in which are found knots or glands of the same substance, or of another. The whole is united by a confused crystallization. Sometimes the spaces occupied by the knots are found empty, the substance which once filled them having been destroyed by an unknown cause. This makes the amygdaloids resemble porous lava.

It has been remarked of the basaltic columns in the Cave of Fingal, that although the prisms themselves are unequal, the faces of each are equal to the corresponding faces of the adjacent prisms; that the inequalities which are in relief upon the top or end of one of the prisms, are adapted to the depressions or little cavities on the top or end of the next opposite prism; as if one was moulded into the other. It is also worthy of notice, that in the Island of Staffa, where the prisms are raised one upon the other, like a series of columns, the convex base of the one is inserted into the concave summit of the other, so that the columns appear articulated.

Even when the basaltic rocks present themselves under a less reg-

ular structure, their position alone is sufficient to attract the attention of the geologist. Those masses which, in a confused manner, overlie granite, gneiss, the primary and secondary clay slates; those summits which—sometimes conical, sometimes pyramidal—shoot up in an insulated form, above rocks of a totally different nature; those cements which unite the basalts to various crystallized rocks; the successive transition of argillaceous slate to basalt, and from basalt to other rocks; and lastly, the numerous instances of the disintegration and decomposition of basalt itself, imparting fertility to the surrounding soil:—these are facts, the explanation of which, for many years, exercised the ingenuity of geologists.

It has now been found, both from observations on recent lavas, and direct experiment on melted basalt, that the columnar structure resulted from a kind of crystallization while they were cooling, under pressure, from a melted state. The statements formerly made in opposition to this view, were incorrect, such as that lava is never decomposed; and it has been demonstrated that the trapp rocks are neither more nor less than ancient lavas, erupted when volcanic action was more violent, and the earth's temperature higher than at present.

§ XXXI.—Volcanic* Productions.

Having in the four preceding sections, noticed the most interesting facts regarding the older igneous rocks, we shall conclude this part of the subject with some remarks on the igneous rocks of more recent times. Among these there are some which have been in a state of igneous fluidity; these are called lavas. They run down the sides of the crater, for a considerable distance, and on becoming cool, harden, and are susceptible of being shaped into blocks, or more properly speaking, into plates, from which various ornamental articles are made, and which resemble beautiful polished marble of different colors, but especially green marble.

Lava is generally composed of felspar and augite. When the former predominates, it constitutes *light-colored, felspathic*, or *trachytic* lava; if the latter is in excess, it constitutes *dark*, *augitic* or *basaltic* lava. Some lavas have a vitreous structure, as the obsidian or agate of Iceland, which has completely the appearance of glass. Volcanic glass has often an enamelled or pearly appearance, and is found in a capillary form.

The *pumice stone* is the best known of volcanic productions. It

* It should be understood that the terms volcano and volcanic are applied only to the volcanoes of the present epoch, unless the contrary is expressly mentioned.

is simply vesicular trachytic lava, and may be considered its froth. *Scoriæ* are vesicular basaltic lava. Both are produced by the access of steam or other gas to the lava.

Pozzuolanas have not, like lava, experienced an igneous fluidity. They are substances of a more argillaceous nature than those which have formed the lava. Having less sulphur in their composition, they have been able to resist the action of fire, which, instead of scorifying them, has only served to calcine and burn them. Heavier than the scoriæ, they fall near the centre of the volcanic mountain. United to lime, they form a cement of the greatest hardness and durability, which the Romans used in preference to every other in the construction of their aqueducts.

Volcanic ashes are discharged from the craters, in the midst of a column of smoke, and are then driven by the winds to great distances. Those of Etna are carried to Malta, and even to Africa. When these ashes are still suspended in the atmosphere, and when the vapors which are at the same time dissolved in it, happen to condense, the mixture which thus takes place occasions those earthy showers which fall at a great distance from the volcanoes. These ashes, from the extreme minuteness of their particles, introduce themselves everywhere, entering even into closets where provisions are kept, and vitiating every article of food; but this inconvenience is compensated by the advantage which accrues from their fertilizing the grounds ravaged by burning torrents of lava.

Volcanic tufa is a substance produced by the agglutination of volcanic ashes, or fragments of scoriæ. The muddy eruptions which take place in certain volcanoes, or the infiltration of limestone, supply a cement. Masses of clay, or liquid mud, in rolling over the cinders thrown out by volcanoes, incorporate with them. At other times, the volcanic substances, in flowing into the sea, may be agglutinated there, by a stony cement held in solution by salt water.

§ XXXII.—Stratified Rocks.

After what has been already said, we need only describe the composition and structure of the principal rocks, of this most extensive and important class.

Gneiss is only granite which has been disintegrated and stratified by the agency of running water.

Mica slate is a mixture of mica and quartz, in which the former predominates. This rock is of very common occurrence, and often abounds with garnet and staurotide.

Primary limestone is generally pure carbonate of lime, white and

crystalline, and hence sometimes termed *saccharine;* but sometimes it is dark and earthy, from being mixed with other rocks.

Talcose slate consists essentially of talc, sometimes mixed with felspar, limestone, and hornblende.

Hornblende slate consists mostly of hornblende, often mixed with felspar, quartz, or mica.

Quartz rock is composed of quartz, either pure, or mixed with mica, felspar, talc, hornblende, or clay slate.

Clay slate (otherwise called *argillaceous clay* or *schist,*) consists mostly of pure alumina, of a fissile structure; but some varieties contain other substances.

The preceding list includes the most important of the rocks variously termed *primary*, *non-fossiliferous* and *azoic*. They follow no regular order of superposition, and are all of unknown thickness. They are all distinguished by their hard, crystalline structure, the absence of all remains of plants or animals, and their passing insensibly into each other. They are always situated below, and never above fossiliferous rocks. All the following rocks contain organic remains, and occupy the positions here assigned to them, beginning with the lowest.

The *protozoic* rocks consist chiefly of clay slate, and limestone, with some sandstone, the latter being composed mostly of quartz. This system is largely developed in Wales, and in New York state; and hence it is sometimes termed the *Silurian* and *Cambrian*, and the *New York system*. It is also called the *graywack* and *transition* system. The rocks are hard, and sometimes crystalline. The total thickness of this class exceeds 20,000 feet.

The *deutozoic* rocks consist mostly of coal, sandstone, and limestone, with some slates, gritstones, and rock-salt. The rocks of this class are still firm, though softer than those below; but the crystalline structure seldom occurs. From the abundance of coal in this series, it is often termed the *carboniferous* system. Its thickness is estimated at about 17,000 feet.

The *tritozoic* rocks consist mostly of sandstone, generally colored red by the peroxide of iron; but limestone, marl, and gypsum occur, and a large quantity of rock-salt. The thickness of the whole is about 900 feet.

The *tetrazoic* rocks consist mainly of lime, under various forms, clay, and sandstone. The rocks of this series are rather soft and perishable. They frequently present an aggregation of small calcareous globules, resembling the roe of a fish; hence they are termed the *oolite* (egg-stone) series. The total thickness is about 3,000 feet.

The *pentazoic* rocks are composed mostly of chalk, intermixed with some green sand, and marl. This, and all the newer rocks, are

decidedly soft and loose. From its constituent element, the pentazoic group is often termed the *cretaceous* (chalky) system, or simply the *chalk*. Its thickness is about 1,500 feet. It is well developed in several parts of northern Europe, but does not, so far as is known, occur in North America.

The *hectozoic* rocks consist of clay, limestone, marl, gypsum, and sandstone, often overlaid with what we have already described under the title of *drift*. This consists of blocks of various kinds of rock, generally intermixed with gravel, sand, and clay. This series is otherwise termed *tertiary* and *supercretaceous*. Its thickness is about 2,000 feet.

The *heptazoic* rocks consist of all modern formations, such as peat bogs, soil, deltas, coral reefs, sand hills, &c. Its thickness varies from a few inches, to 25 or 30 feet.

All the classes above the azoic, contain the remains of animals and plants, each having many peculiar to itself; and this fact is the basis of the classification, which is due to President Hitchcock, of Amherst College.

It must not be supposed that all the series mentioned in this section are found in any one place. They are all wanting in many localities, where the ancient granite overlooks more recent formations. In some countries, however, most of the series occur, the older generally occupying the higher grounds. Thus in England, the western parts consist of azoic and protozoic rocks; and, as we go eastward, we meet successively with most of the subsequent series, till we reach the heptazoic deposits, on the coast of Norfolk. In such cases, the more recent rocks occur as we descend. High mountains generally consist of igneous or azoic rocks, which are often flanked by the protozoic and deutozoic; and the more recent are found in the valleys, or on the plains and sea coasts. Sometimes a very ancient rock is found immediately below one of the most recent, as primary limestone below common soils, several of the series being absent.

All the stratified rocks, except the two latter classes, have been much broken and disturbed by the sinking of some parts, and the elevation of others. This is particularly true of the older rocks, which frequently present evidences of the wildest confusion, and most terrible upbreakings. All of these classes are more or less inclined, and the strata are sometimes quite vertical. The more recent rocks are generally less inclined, and frequently horizontal.

PART V.

PALÆONTOLOGY, OR DESCRIPTION OF ORGANIC REMAINS.

§ I.—Classification of Fossil Remains.

The fossil remains of organic beings may be viewed as so many geological medals, but medals without a date. They may be distributed into three classes, viz., remains which have preserved their natural state, at least in part, petrified substances, and impressions.

The first class consists principally of bones, and even of whole skeletons, which, after having been deprived of the skin and flesh that covered them, remain buried in the earth or concealed in deep caverns. Sometimes they are calcined totally, or in part, without having lost their configuration; sometimes they retain not only their texture, but even a certain portion of skin and flesh. We occasionally find them incrusted with a calcareous covering.

Petrifactions, taking this term in the ordinary sense, comprehend all the stony substances which have the figure of an organic body. There have been instances where a liquid, impregnated with stony particles, has flowed into a cavity formed by an organic body, which had disappeared. In that case, the stony mass has flowed into the empty cavity, and assumed the exterior form of the organic body which was there before. If this body was, for example, a branch or trunk of a tree, the stone will have knots and wrinkles on its exterior, but in the interior it will exhibit all the characters of a real stone. It will only have the form of the substance which it has replaced. While the process of decomposition is going on gradually, and obviously in a vegetable or animal substance, it is sometimes surrounded by a fluid containing solid matter in solution. As each organic particle dissolves and disappears, a stony particle replaces it. Thus, particle after particle, the stony substance gradually occupies the spaces left vacant by the progressive decay of the vegetable or animal parts; and, being moulded in these cavities, it copies, feature for feature, the contexture of the organic body. This is the way in which it is usual to explain the formation of *petrified wood*, an imitation so complete of the real

wood, that upon cutting it transversely, we distinguish the appearance of concentric rings, which, in the living tree, arise from its annual growth. Sometimes we can ascertain, even by the lineaments of the texture in this petrified state, the species to which the tree belonged.

In a similar manner any other mineral may take the place of the original substance. Thus, the turquoises, for example, are the jaw teeth of some large sea animal; a metallic substance which has penetrated them has been gradually substituted for the softer part of the bone.

The principal mineralizers are limestone, silica, clay, and the oxides or sulphurets of iron. The ores of other metals are of comparatively rare occurrence. Limestone is the most general of all.

Impressions are found between the laminæ of certain argillaceous slates; they are the moulds representing skeletons of animals, particularly fish, leaves, reeds, and entire plants, especially of the fern kind.

To all appearance, as Brugnieres explains it, the fern placed upon soft clay has been covered over again with a new deposit. Afterwards, this plant, reduced into a carbonaceous substance or penetrated by the minute particles of the schistous deposit, becomes incorporated and identified with it; and, as the surface of the fructifications is unequal, that opposite being more smooth, it is natural to imagine that there has been less cohesion between the clay and this smoother face. Hence the reason why this latter face generally presents itself when the leaves of the clayey schists are separated. We shall now speak successively of the different classes of fossil remains.

§ II.—Vegetable Remains.

Sometimes only the exterior forms of the vegetables are perceptible; at other times the different rings of the wood and bark are to be distinguished. They have been found on heights where they do not grow. A trunk of a petrified tree has been met with upon Mount Stella, in the Grisons, 4,000 feet above the level where the last shrubs grow. Some have been met with, which present to us the most delicate traces of the structure of flowers. They sometimes represent indigenous plants, or such genera as are natives of neighboring countries; but those of temperate regions have more frequently a tropical, or ultra-tropical character. Bernard De Jussieu res marked, about a century ago, that the greater part of the fossil plant which are found in the bituminous slates of Saint Chaumond, near Lyons, were foreign to that climate.

Délamethrie has shown, that the elastic fossil gum of Derbyshire was the caoutchouc, which now grows only in Peru. The fossil plants of the coal formation exhibit tree-ferns and palms much larger than any now found on earth; and such remains have been found as far north as Melville Island, in latitude 75°. The largest of living lycopodiaceæ, or club-mosses, for example, are only 3 feet high, while the fossil are found 70 feet high; and fossil-tree ferns occur 50 feet high. The recent equiseta are seldom more than half an inch in diameter, whereas the corresponding genus in the old rocks was sometimes 14 inches in diameter. As we ascend higher in the rocks, vegetation gradually becomes more like that of the present day. In the oldest rocks flowerless plants predominate. In the deutozoic period, ferns, pines, palms, and club-mosses were the principal plants, giving the earth a very imposing, but sombre appearance. Many of the fossil plants are entirely unlike any existing species—such as the calamites and the sigillaria. Some genera, again, are found in almost every period, such as the pines and palms; although they were comparatively much more abundant in the earlier period. The number of species of plants already discovered amounts to nearly 12,000.

§ III.—Fossil Shells.

Among the remains of the animal kingdom, shells are the most abundant. They are found in all the great formations; but are most abundant in tertiary and calcareous rocks. France furnishes us with numerous examples.

The environs of Paris alone supplied Lamark with more than 60 species. In the environs of the town of Rheims are found quarries, filled with transparent belemnites, with sea urchins, and with pyrites of different forms. There, likewise, are to be found, in mingled confusion, cornua ammonis, fossil talc, petrified wood, and pieces of potter's earth, full of impressions of leaves. The Canton of Courtaquer presents a bank of more than 60 kinds of shells, of more than 20 miles in length, and nearly 6 in breadth. It contains a number preserved entire, and some have even retained their polish and their color. All the plains of what was formerly called the Isle of France, present vast banks of calcareous and sandy stones, filled with, or rather composed of shells, some belonging to the kinds which inhabit our seas, and others different. In Touraine is one continuous bed of broken shells, of about 81 square miles in superficial extent, and 20 feet thick. The whole mass of shells is estimated at 1,360 millions of cubic yards.

The other countries of Europe are not less abundant in fossil

shells. Twenty pages would be insufficient to enumerate the places in Germany where they are found. But there is one general remark of the German geologists, that is highly deserving of attention. The calcareous and slaty transition rocks in the chain of the Hartz Mountains, contain only zoophytes, such as madrepores, millepores, and terebratulites. The stratified rocks, considered the most ancient, contain zoophytes, belemnites, ammonites, encrinites, pentacrinites, and, in a word, shells the most remote from the actually existing kinds. On the contrary, the most modern calcareous rocks, those of Mount Bolca, near Verona, and the hills of chalk, in England and Zealand, enclose kinds approaching to those which now exist,—such as the ostracites, pectinites, buccinites, nautilites, chamites, and others.

The north and south of Europe do not yield to the central parts in this respect. The calcareous rocks of Rœtwick, in Sweden, 3,000 feet above the sea,—the vegetable earth of Finland,—and the argillaceous beds of Norway, abound in shells, some whole, others almost changed into earth. In Italy we see, near Bologna, a bed of sand formed from cornua ammonis, which are not one line in thickness. In Greece and in Spain we often travel over nothing but shells. Ramond has found them in the Pyrenees, on the summit of Mount Perdu, at a height of 10,578 feet. Lamanon has found them in the Dauphinese Alps, at a height of 7,446 feet; Guerin, on Mount Ventoux, as high as 6,162 feet; and Saussure, in the Alps of Savoy, at 6,104 feet. It may be affirmed, with certainty, that, throughout Europe, wherever there is chalk there are shells. In Great Britain alone, upwards of 1,500 species have been discovered. Many of these resemble shells that are now found only in the tropical regions; and the same remark applies to the fossil shells of all other countries. No land or fresh water shells have been found below the tertiary rocks.

Everything concurs in leading us to consider the other parts of the world as perfectly similar to Europe, with respect to the abundance of shells. The vast heaps of echini, which exist in Lybia and in Barbary, have been described by Shaw;—and we learn from Rœmer, that shells are found in the gold mines of Akim, in Guinea. Mount Lebanon is, in a manner, sown with echini, and Mount Carmel with petrified oysters. In the chains which border on the Caspian Sea, shells are found even at a height above the region of the clouds. We see beds of them interspersed among the rocks of Mount Taurus, in Caramania. The mountains of China, according to the Jesuits, are covered with them; and Siberia has offered to Russian travellers, not only calcined, but pyritized shells, and also madrepores. The sphinx and some of the Egyptian pyramids are composed of limestone, which so abounds with nummulites, or coin-shells, as to be termed nummulitic limestone. The plains of Hindostan abound with fossil shells.

The coasts of Timor, of New Holland, and a great many other oceanic lands, are composed in great measure of accumulations of marine testaceous animals.

With regard to America, the United States and Canada contain enormous beds of calcareous matter, abounding with shells, especially the sea-board states. Humboldt observed the high chain of the Andes covered over with ostracites, or petrified oyster shells, at an elevation of 13,200 feet.

Considering that they must have existed many thousands of ages ago, the perfect preservation of shell fish is sometimes surprising. Species resembling the cuttle-fish, for instance, have been found with the ink-bag as good as if the animal had just been caught.

§ IV.—Fossil Fish.

The remains of other sea animals are less abundant. Next to the testaceous kind, fish are the most frequent. They are found in Switzerland, near Glarus, in the clay slate; in Germany, in marly slate; in Egypt; in Syria; in the calcareous rocks of the coast of Coromandel, and in several mountains of China. But perhaps no place has furnished a greater number than Mount Bolea, near Verona, in Italy. France has furnished some very curious specimens. There has been discovered at Grandmont, in Burgundy, a fish in a mass of gray, calcareous stone. Another, which was 10 inches, 10 lines long, has also been found in a solid bed of stone, at 17 feet depth, at Nantérre, near Paris. It belongs to a tribe similar to those which live in the equatorial seas. Upwards of 500 species of fossil fish have been discovered in Britain.

Shark's teeth are found almost everywhere, sometimes adhering to the maxillary bone. The calcareous rocks which border all the coasts of the Mediterranean, afford them in great quantities; they are frequently seen in Livonia, in the Uralian Mountains, and in the steep shores which form the margin of the rivers of Siberia. One of an enormous size was found in North Carolina. From the size of the tooth, the shark must have been from 70 to 100 feet long. Sharks seem to have abounded during every geological period; and more than 150 fossil species have been discovered. In all the rocks below the pentazoic or chalk, the fishes are all destitute of scales, and are covered with bony plates, whereas the existing species are mostly covered with scales. Those of the older rocks further differ from most of the existing species in being *heterocercal*, that is, they have the spine running into the upper part of the tail, which is much longer than the lower lobe, as in the shark; whereas the *fish of the present* period mostly have the tail homo-

cercal, that is, the two lobes are equal, and the spine does not extend into either, as in the salmon. The largest fishes of the older rocks further differed from most of those of the present period in resembling lizards in the formation of the skull, spine, teeth, and skin; and hence they are termed *sauroid*, (lizard-like.) Some of them must have been larger than crocodiles. Only two living genera of this kind are known.

The different formations described in the last section of the preceding part are characterized by peculiar species of fish; for the same species has never been found in any two of them. Another remarkable fact is, that they do not change gradually, as we pass from one formation to the other, but abruptly; and these changes were simultaneous with changes in other animals, and in plants. This indicates that existing species were suddenly destroyed by a general upbreaking of the earth's surface, and other species soon after created, more suited to the altered condition of the globe. The present period forms the seventh, which exhibits its own peculiar animals and plants.

Fish are found in all the great formations, from the protozoic upwards, which is not the case with any other class of vertebrates. Agassiz reckons the number of species of fish that existed during all the geological epochs at 30,000. The number of living species known is only about 8,000.

Under this head we may mention a kind of crustaceous animal, formerly very prevalent, called the *trilobite*, because they were divided by longitudinal furrows into three lobes. They appear to have swarmed in the waters of the protozoic period, as more than 200 species have been discovered in its rocks. The whole class disappeared with the deutozoic or next period, which exhibits only a few species. No such animal appears to have existed for countless ages. The largest ever found was in Ohio. It is 19½ inches long.

Some fish have been forcibly and suddenly enclosed in the substance which contained their impression, or their cast in petrifaction. We can still perceive the violent and convulsive contortions into which these animals had thrown themselves, to escape the terrible catastrophe of which they are the monuments.

§ V.—Fossil Reptiles, Insects, and Birds.

The fossil remains of reptiles are very numerous and interesting. The most important are those of the *saurians*, animals of the lizard kind, which first appear in the deutozoic or carboniferous period, although they do not become numerous or important till we come to *the tetrazoic* or oolitic period. Of this epoch, they appear to have

been the ruling animals. No less than 28 species have been found in Britain alone, mostly in the tetrazoic rocks. One of the most interesting is the *ichthyosaurus*, or fish-lizard, sometimes upwards of 30 feet long. It had the snout of a porpoise, the teeth of a crocodile, the head of a lizard, the backbone of a fish, the breastbone of an ornithorhynchus, and the paddles of a whale. The orbit of the eye in one species, was 14 inches in diameter. The length of the jaws sometimes exceeded 6 feet. The eye had a contrivance by which it could see by night as well as by day. It inhabited the ocean. Ten species of this singular animal have been discovered. The *plesiosaurus*, (neighbor-saurian,) resembled the former in many respects, but it was much smaller, the largest skeleton yet discovered being only 11 feet long, and its neck was much longer. It was also a sea animal. Of this kind 16 species are known.

The two preceding genera disappeared with the tetrazoic period; and they are succeeded in the next by the *mosasaurus*, or saurian of the Meuse, so called from its remains having been found on the bank of that river. Remains have also been found in England. This animal was about 25 feet long, and disappeared with the chalk. Like the two preceding genera, it was marine.

Of land saurians, one of the most remarkable was the *megalosaurus*, (great saurian,) which somewhat resembled the crocodile, and was 30 feet long. Its teeth combined the principles of the knife, the saw, and the sabre. At the same time lived the *hylaeosaurus*, (wood saurian,) a similar animal, about 25 feet long.

All the above saurians were carnivorous. The *iguanodon*, (iguana-toothed,) was a kindred animal, but herbivorous. It is the largest land animal whose remains have yet been discovered. Its length was 70 feet; girth of body, 14½ feet; of thigh, 7 feet; and length of the hind foot, 6½ feet. Its remains were found in the south of England. The above length was made out from comparing the bones found with those of the iguana, which it greatly resembled, as no complete skeleton has yet been found. Another very large animal of this class was the *cetiosaurus*, (whale-lizard,) which was 60 feet long.

More strange, though much smaller than the preceding, was the *pterodactyl*, (wing-fingered.) To call it a winged lizard, would only express a small part of its anomalies: for it had the beak and neck of a bird, (though the beak was singular in having some sixty sharp teeth,) the wings of a bat, and the body and tail of a mammal. The forearm was elongated to support the membranous wing, from which projected fingers terminated by long hooks; its eyes were of enormous size. Eight species have been discovered, the largest being about the size of a cormorant. Its remains were found in England and in Germany.

Tortoises of all kinds have been found fossil, in all the rocks above the carboniferous. Some of these were of huge size, one whose remains were found in India measuring 20 feet across. The whole number of species of reptiles discovered exceeds 300. *Insects* first appear in the deutozoic or carboniferous rocks. The number of species found fossil, (about 70,) bear no proportion to those of the present period: but we must not infer that they were not numerous in early times; for their frail and light bodies are not so easily preserved.

No remains of *birds* have been found lower than the tetrazoic rocks; but Professor Hitchcock discovered the footmarks of many species on tritozoic rocks, in the Connecticut valley. Some of these were very small, and others of enormous size. In one instance, the footmark was 17 inches long, and the step 4 or 5 feet; in another, the mark was 2 feet long, and the step 6 feet. This would indicate that the birds were much larger than any existing species. Only about 50 fossil species of birds have yet been discovered; but they probably bore as great a proportion to other animals formerly, as they do at present; for their power of flight would prevent them from perishing in circumstances where their remains were likely to be preserved.

§ VI.—Fossil Mammals.

With the exception of a few remains of marsupials, (the lowest class of mammals) found in the tetrazoic rocks, no remains of mammals have been found below the hectozoic or tertiary rocks; but here they suddenly become very abundant. The genera are the same as those of the present period; but they are of a larger size, and of a different species. The genera were very numerous, and included horses, cows, deer, sheep, goats, lions, bears, wolves, hyenas, hares, rabbits, mice, rats, elephants, mastodons, rhinoceroses, hogs, and cats. The remains of quadrupeds are found accumulated in regions where similar animals do not now exist. Some are buried deep in beds of gypsum, such as the *palæotherium*, (ancient beast,) and the *anoplotherium*, (unarmed beast,) which Cuvier may be said to have resuscitated, and which, with their different varieties, are found in beds of sand in the environs of Paris. The former genus was like a horse, but more thick and clumsy; the latter resembled the deer. Others are met with in beds of sand or marshy ground, as the greater part of the bones of elephants, the *megalonyx*, (great onyx,) an unknown animal of the sloth tribe, having the shape of an ox, and found in Virginia; the *megatherium*, (great beast,) found near Buenos Ayres and Georgia, and having the character of the sloth, with a

bulk larger than the rhinoceros. Its body was 12 feet long and 8 high; it measured 5 feet across the haunches, and its thigh bone was nearly thrice as thick as the elephant's. There are some which present themselves to view, accumulated in vast caverns, and destitute of any envelope; it is thus that the fossil bear has been found in the caverns of Gailenreuth, in Germany. The fossil remains of this genus are spread, as well as those of marine animals, all over the face of the globe. The fossil elephant, which is of a species entirely different from those of the present day, has left proofs of its ancient existence in all Europe, in northern Asia, and in North America. We know that Siberia always exports annually a great quantity of fossil ivory, a substance which abounds in that country. It is almost always seen where the waters of the rivers undermine the light soil which forms their borders. The Islands of Lachov, situated to the north of Siberia, are, according to a modern traveller, only heaps of sand, ice, and bones of elephants and rhinoceroses, mixed with those of great cetaceous animals, and even, agreeably to the latest accounts, with the remains of gigantic birds.

There have been found in Siberia whole carcasses of the species of elephant called *mammoth*, covered with flesh and skin, which the frost that prevails in these regions has preserved entire. In Europe, the greatest number of these have been found in Germany, Italy, France, and Britain.

Some elephant's bones have been brought from the upland plain of Quito, by Humboldt. It has been estimated that from the Big Bone Lick, in Kentucky, alone, the bones of 20 elephants have been carried away.

Next to the mammoth, or fossil elephant, we should mention the *mastodon*, (teat-toothed,) an animal nearly similar to the elephant, and like him, graminivorous, but distinguished, besides other peculiarities, by the form of the teeth. This animal, which is sometimes confounded with the mammoth, or fossil elephant, (of which there are five distinct kinds, all unknown in a living state,) has left its imposing and astonishing remains upon both continents. At least seven species have been found fossil, (some say 13,) three in Europe, one in India, two in South America, and one in North America. That found in North America is the largest. It is upon the banks of the Ohio, and of the Hudson, or North River, that the best specimens of the mastodon have been found. They have also been met with in Louisiana. Two nearly complete skeletons were found in Orange County, New York. That found near Newburgh, in 1845, is perhaps the finest ever discovered. It was found in a peat bog, with marl below. Its weight is nearly one ton.

The fossil bones of the *rhinoceros* and *hippopotumus*, are found in the vicinity of the remains of the elephants. The most remarkable

remains of the rhinoceros, is the head, which has been taken out almost untouched from the turf pits, on the Wiloni, a river of Siberia.

Besides the megatherium, already mentioned, another remarkable animal, allied to the sloth, was the *mylodon*, (mill-toothed,) whose pelvis was larger than the elephant's, and whose tail was so remarkably large and strong that it probably used it for support in sitting. Its remains are found in South America.

Of all the mammals that ever existed, the largest, as far as we know, was the *dinotherium*, (terrible beast,) an animal resembling the tapir and the mastodon. Its remains have been found in France, Austria, and Central Germany. Its length must have been about 18 feet. It had two enormous tusks, like those of the walrus, on the lower jaw, 4 feet long. It is supposed that it lived chiefly in the water, like the hippopotamus.

The horns of fossil oxen are found 31 inches long; and those of the fossil elk were more than 10 feet asunder at the tips. A perfect skeleton of this animal was found in the Isle of Man. It is now in the University Museum, at Edinburgh, beside that of a large Swedish elk, which looks very puny beside it.

Many fossil mammals have been preserved in caverns. Sometimes they appear to have retired thither to seek a shelter from some sudden revolution, the irresistible violence of which, notwithstanding, involved them in general destruction. At other times they seem to have lived there; for the cavern is full of the gnawed bones of prey, which they seem to have dragged into their dens. The bones are sometimes encrusted in stalagmites. Caves of this kind occur in England and in Germany. The remains found in the latter are chiefly those of bears, one kind of a huge size. The caverns sometimes appear to have been inhabited by these animals for a long series of ages, as in one instance several thousand skeletons were found in one cave. In the English caves the remains of hyenas are common, an animal not now found in Europe. And it may be remarked, that in general, organic remains frequently differ very widely from those of living animals in the vicinity, or even in that quarter of the globe.

The occurrence of drift at the mouth of caverns containing bones, and sometimes within them, indicates that the animals whose remains are there entombed, perished by a sudden rush of waters. The supposition we formerly mentioned regarding the cause of the drift, sufficiently accounts for the sudden disappearance of so many species throughout the northern regions. The hypothesis of a sudden revolution in the temperature of the globe is not only contradicted by the nature of the flora, but unsatisfactory otherwise. For it would have still permitted the animals to seek another habi-

tation. Nothing besides, in the structure of these animals, positively announces that they could not have lived in a cold climate: only the quantity of nourishment which some of those huge animated masses required, and their numbers, proved by the existence of the carnivorous kinds, render it probable that the countries where we find their remains once enjoyed a temperature, if not warmer, at least more favorable to vegetation.

The total absence of human bones, in these different collections of remains, proves that man did not exist anterior to the last revolution of the globe. Some human remains have indeed been found in ancient rocks, but only in cases where they were placed there for interment. As every geological epoch witnessed the introduction of a higher class of animals, the present—and in all probability the last, while this globe endures—witnessed the introduction of Man, who, with all his defects, is still "the chiefest work of God below."

DIVISION FOURTH.

METEOROLOGY, OR DESCRIPTION OF THE ATMOSPHERE, AND THE PHENOMENA DEPENDENT ON HEAT, LIGHT, AND ELECTRICITY.

PART I.

DESCRIPTION OF THE ATMOSPHERE, AND ATMOSPHERIC PHENOMENA.

§ I.—Preliminary Remarks.

Having gratified our curiosity with contemplating some of the wonders of the earth, we proceed to the consideration of the vast fluid with which it is surrounded, and which may be said to constitute an integral part of the globe itself. This celestial ocean, which is called the *atmosphere*,—that is to say, *the sphere of vapors*,—forms the subject of our present discussions.

The atmosphere is the grand laboratory of nature, in which the various gases exhaled from our globe are collected together, and distilled, mixed, decomposed, volatilized, condensed, or precipitated in an endless round, according to fixed laws. All terrestrial beings pay tribute to the atmosphere; all receive from it the principles necessary for life. There is perhaps no substance which could not be reduced to the aeriform state by intense heat, and which could not be rendered solid by intense cold. Were this planet transported into the temperature which Mercury possesses, a part of our sea and of our land would evaporate and mingle with the atmosphere; and, on the other hand, should our globe, at any time, wander towards the cold regions of Saturn or Uranuus, a great portion of the vapors in our atmosphere would be condensed, and pass to the solid form. Our atmosphere, therefore, may be thus defined:—the assemblage of all substances capable of preserving the aeriform state, at the degree of temperature which prevails around the terrestrial globe.

The atmospheric fluids may be divided into three classes: the

first comprehends pure air, or atmospheric fluid, properly so called; the second consists of aqueous vapor and carbonic acid, which are always present in the atmosphere; and the third is composed of the various gases occasionally suspended in it, and which differ widely in different localities.

The color of air is a fine light blue. But the atmosphere of various countries derives a peculiar tinge from the vapors it contains, the degree of rarefaction, and the amount of solar light which falls upon it. In cold countries, its blue is generally less brilliant, because it is seldom free from vapors, and the light is more feeble. For these reasons the sky of France is of a clearer blue than that of England; that of Italy surpasses both; and this is very inferior to the crystalline cerulean of the isles of the Pacific.

§ II.—Composition of the Air.

Common air, which forms the greatest part of the atmosphere, is not a simple element. Modern chemistry, by analyzing and again compounding it, has proved that there are two substances which necessarily enter into its composition in very different proportions, viz.: oxygen and nitrogen, otherwise termed azote.

The essential properties of air depend on these two gases; but as steam, or aqueous vapor, and carbonic acid gas are always present, they are properly considered constituents of the air. The quantity of carbonic acid is always uniform where there is a free circulation of air, being the same at the sea level and on the tops of the highest mountains, at the poles and under the equator. The quantity of aqueous vapor differs widely, according to circumstances; but it is generally within certain moderate limits. Professor Brande, of London, gives the average ordinary constitution of the air as follows, omitting the third class of substances mentioned in the preceding section:—

	By measure.	By weight.
Nitrogen,	77.50	75.55
Oxygen,	21.00	23.32
Aqueous vapor,	1.42	1.03
Carbonic acid,	0.08	0.10
	100.00	100.00

Such a compound forms a very pure, healthy air.

Some think that because hydrogen, or inflammable gas, is much lighter than air, it must rise to the upper regions, and form an envelope around the atmosphere. This is one of the many erroneous

opinions apt to be held by sciolists. Gases diffuse themselves through each other till they are intimately blended, no matter how much their specific gravities may differ; and no gas thus diffuses itself more rapidly than hydrogen, the absence of which from the lower regions of the atmosphere, therefore, proves its non-existence in the upper. The little that occasionally escapes into the atmosphere, is gradually united with oxygen, by means of the electricity which is in constant operation in every part of the world, and thus converted into water.

The principal other gases occasionally intermingled with the air are carbureted hydrogen, (otherwise termed *marsh gas* and *fire-damp*,) and sulphureted hydrogen, or hydrosulphuric acid. Both of these are poisonous; but they indicate their presence by a disagreeable smell, that of the latter being particularly so. Air, however, is more frequently corrupted by the presence of an undue amount of carbonic acid, which miners call *choke-damp*. This is destitute of any disagreeable smell, and hence produces much more mischief than the others, although it is not nearly so poisonous as sulphureted hydrogen. It is carbonic acid that causes death in close rooms, or such as are heated by charcoal furnaces, and in mines and pits. It is also the cause of the headaches and drowsiness which are experienced in crowded rooms, public and private. It always accumulates rapidly in such places, without a much more efficient system of ventilation than is usually thought sufficient. The very small quantity generally present in the atmosphere, produces no bad effect; but when this has been increased tenfold, its agency becomes very injurious; yet in such places as those just mentioned, it is generally increased more than fiftyfold, while the vital oxygen is withdrawn. It would, therefore, be well if people would look nearer home, before speculating about the "inflammable gas in the upper regions."

It is only oxygen gas which is consumed by animals in respiration But if it existed in too great proportion, it would be the means of exciting our vital spirits to such an excessive degree, that exhaustion and death would soon ensue. On the other hand, nitrogen, or azote, (as the latter name indicates, a-zōtikos, not vivifying,) is incapable of supporting animal life. It is, then, the mixture of these two gases, oxygen and nitrogen, that renders the atmosphere so favorable for animal existence. The nitrogen has no bad effects upon the system, while it tempers the action of the oxygen, which is too violent when diluted to a less degree, while a greater proportion of nitrogen would render the air too feeble in its action. These facts have been proved by many experiments on mixtures of these two gases in different proportions.

§ III.—Effects of Respiration and Combustion on Air.

Plants inspire carbonic acid and exhale oxygen gas—only, however, when they are exposed to the light of the sun.

Carbonic acid is a compound of oxygen and carbon, which plants decompose. The carbon goes to nourish their tissues, which are a compound of carbon and water; and they return the oxygen to the air. The action of animal respiration is the reverse: animals require oxygen, both to stimulate the organs to due action, and to generate heat, by uniting with the carbon existing in the blood. When these two substances unite, much heat is always produced; and the result is carbonic acid. This is extremely poisonous to animals. Hence they are throwing it off incessantly by expiration. The effects of combustion, or burning, on air are identical with those of animal respiration: for the carbon of the fuel unites with part of the oxygen of the air, and produces carbonic acid. We may now see the beautiful arrangement by which the air is rendered fit to supply the wants, both of plants and of animals, and innocuous to either. Plants take up carbonic acid, which is poisonous to animals, and obtain from it the carbon requisite for their growth, while they return to it the oxygen required by animals. The latter take up the oxygen, and return carbonic acid for the use of plants.

§ IV.—Color and Weight of the Air.

The air is a fluid so extremely rare and subtle, that it becomes sensible to the touch only when in motion,—for example, when the wind is blowing. In its state of purity it is equally tasteless and inodorous. Although, when we view a small portion of air, it appears colorless, yet it has a fine blue color; and "the blue sky" is, in reality, nothing but the blue air; and the blue appearance of distant land is owing to the color of the intervening air.

The ancients thought that air had no weight; but Torricelli, a pupil of Galileo, demonstrated the contrary. The air-pump, the ascent of water in a suction pump, and the elevation of mercury in the barometer, are all so many proofs of this fact. The mean pressure of a column of air, reaching down from the extremity of the atmosphere to the level of the sea, is equal to the weight of a column of mercury of the same thickness, and of nearly 30 inches in height; but it ranges from 28 to 32 inches. Take a tube of glass 2 feet 11 inches long, and about 2 lines diameter, closed at one end, and open at the other; fill it with mercury, applying your finger to the orifice; invert the tube, and place the open end in a basin containing mercury; with-

draw your finger, and you will observe, at the same moment, the mercury descend in the tube, to the height of 29 or 30 inches. In the same manner, in our common pumps, the water rises to a height of 32 or 34 feet. Now this height is to the height of the mercury, in the inverse ratio of the densities of water and mercury. One and the same cause operates here. It can be nothing but the weight of the external air which balances the mercury in the basin, and the water in the pipe. The average weight of the air at the sea level, as thus ascertained, is 15lbs. on the square inch; being more than 800 times lighter than water. As we ascend, the pressure of the air diminishes at first so that the barometer falls about $\frac{1}{10}$ of an inch for every 75 feet; but afterwards it diminishes more rapidly.

The pressure which the air exerts on a man, the surface of whose body is 15 square feet, is nearly 33,000lbs.; and the variation of a single line in the height of the mercury, produces a change of upwards of 130lbs. in the pressure of the air. The diminution of the weight of the air on very high mountains, combined with other circumstances, occasions vertigoes, nausea, hemorrhages, and a feeling of general uneasiness. The air exerts a pressure equal on all sides; otherwise fragile bodies would soon be broken. The moment that the equilibrium of its parts is destroyed by any cause, this property produces an instant exertion to re-establish it, and this is the principle of all its movements.

§ V.—Elasticity and Height of the Air.

The elasticity of the air is the property which it possesses of resisting the force of compression, and of recovering its original volume, or even a volume of greater dimensions, as soon as the compressing force ceases to act. We cannot exactly compute the limits of the compressibility and the expansibility of the air; we know, however, that they are of vast extent. Boyle affirms, that without the assistance of heat, he has dilated air 13, 766 times. Every one knows the manner in which air is compressed in an air-gun, and the force with which it can thus be made to impel a ball. Mariotte discovered, that the temperature being the same, the pressure, or elastic force of air, is directly as its density, and inversely as the space it occupies; and the same is true of all other permanent gases. Hence the denser the air, the greater is its elastic force, and *vice versa;* so that, as it expands from diminished pressure, the power to expand becomes gradually less.

Its rarefaction in the upper regions must therefore have limits; for as we ascend, the force of gravity diminishes so slowly and that of the air so rapidly, that we shall come to a point where the one will

exactly balance the other. This will be the limit of the atmosphere. But as we do not accurately know the law of the progressive rarefaction, we are unable to determine the precise height of the atmosphere from such data. Another difficulty is that the cold in the upper regions interferes with Mariotte's law, and makes the height much less than it would be if its temperature were uniform: for the elasticity of all gases rapidly diminishes on the application of cold, as it increases by the application of heat. By observing the sun's position at the beginning or end of twilight, which is about 18° below the horizon, we can determine the height at which the atmosphere begins to refract the rays of solar light; and as light is so ethereal, and so easily refracted, we may fairly infer that there, or at least a little above, are the limits of the atmosphere. This gives it a height of about 45, or at most, 50 miles.*

The atmosphere is supposed to be higher at the equator than at the Poles, but we have neither data for computing the various heights, nor the proportion in which they differ.

§ VI.—Temperature of the Air.

The temperature of the atmosphere has a great influence upon most meteorological phenomena; but it is exceedingly variable, and as yet can only be determined by actual observation on the spot. Nothing could tend to throw a greater light on many of the unresolved questions in meteorology, than a ready mode of computing with certainty the temperature which obtains at any instant, in a point of atmosphere remote from the earth's surface, and at any point on the surface remote from the observer; but these are likely to continue desiderata.

What is known of the temperature of the air, remote from the earth's surface, has been derived from aeronautic expeditions, and particularly the unexampled ascent of Gay Lussac to the height of 23,040 feet.

Leslie estimates that the temperature of the atmosphere diminishes 1° Fahrenheit, for every 100 yards of ascent. This, however, is true only near the sea level. The decrease of its temperature is owing to increased rarity; and hence it is more rapid in the higher regions, so that at the height of 5 miles, it is 1° for every 200 feet. Many circumstances, however, interfere with the rate of decrease, which is seldom uniform in two distant places, or in the same place at different times. The figures just given, are only mean approximations for temperate climates.

* There can be little doubt that there are atmospheric tides, similar to those of the ocean: but they are neither sensible nor important.

Mr. Dalton, about the commencement of the present century, proposed a theory of gradation of heat in the atmosphere, on the supposition that the same weight of air, taken anywhere, in a vertical column, contains the same quantity of heat; and hence, he concluded, that the temperature ought to be regulated by the capacity of the air for heat at the particular density. This theory seemed very plausible at the time it was advanced, and agreed well with what was supposed to be known of the variable capacity of the air for heat. But simpler and more accurate experiments have shown that the decrease of temperature, due to rarefaction, far exceeds that observed in aeronautic ascents; and, therefore, if such observations are to be depended upon, there must be other causes which interfere with Dalton's theory.

The heat of the air, in one shape or other, is no doubt greatly derived from the sun, either immediately, by intercepting the solar rays, or indirectly, from its contact with the earth's surface, which is more or less heated, according as it is turned more or less towards the sun; and thus the various parts of the air are heated unequally. Again, since the currents in its upper regions usually come from a warmer quarter, and the lower currents from a colder quarter, the decrease of temperature, on ascending in the atmosphere, is slower than the law of capacity, as increased by dilatation, requires. Sometimes, however, the case is reversed.

As a lower temperature obtains in elevated situations, owing to the increased rarefaction of the air, so an increased temperature generally prevails in air occupying deep caverns and mines, owing to increased density of the air, independent of other influences. There are some mines intensely cold, and as these were first observed, the explanation offered was, that the colder portions of air had, by their greater weight, descended into the mines. But this solution entirely vanished when it was known that mines are generally warm. The heat of the workmen, their fires and lights, have been stated as sources of heat, as likewise the chemical action of air and water on the minerals.

This sufficiently proves that whatever be the sources of heat, some of them at least must operate in, or be situated about the mine itself. That a high temperature obtains in the interior of the earth, is, in many instances, evident from the streams of hot water and vapor, which issue from fissures in the strata; but in many warm mines this is scarcely observable. From what is now known of the greater capacity of compressed air for heat, there can be little room to question that this furnishes a considerable supply, although the other causes just mentioned assist more or less in raising the temperature of mines. Thus, if the air at the temperature of 62° F. have its density suddenly increased by the 170th part, the

temperature will be raised 1°, supposing no heat to be lost on the sides of the shaft. This would give 1° for a descent of 170 feet, which is still short of the rate at which the temperature is observed to increase in British mines; but when added to the heat caused by the other agencies described, there does not seem to be any mystery in the higher temperature of mines.

§ VII.—Aqueous Meteors.

Water is incessantly rising from every part of the earth's surface, whether land or sea, in the form of an invisible gas, or as a vapor, which mixes with the air. This process is termed *evaporation.* The amount evaporated greatly varies with the nature of the surface, the temperature of the air, and the amount of water already blended with it. The warmer the air, the more rapid the evaporation, if other things are the same: but where the surface of the earth is dry, the evaporation is much slower than from waters, and the air will only receive a certain amount of vapor at a given degree of heat and density. When it has received this amount, evaporation will cease. If the air now cools, part of the water it contained in the invisible form of steam becomes visible, having assumed the form of water: for, as air cools, the amount of vapor it will sustain decreases: and whenever it contains the greatest amount it will receive it is said to be *saturated*, or at the *dew-point.* Such is the origin of all aqueous meteors.

When a mass of atmospheric steam has been condensed by the cooling of the air, it forms what we usually denominate a *cloud:* if this should rest on a mountain, it is termed a *mist;* if on the plains or valleys, it is a *fog.* If the small drops of mist, under the influence of mutual gravity, unite so as to become too large for the air to sustain them, they fall to the earth, forming *rain.* If the rain freezes when the drops are yet small, it becomes *snow*, which is an assemblage of small crystals of ice: if they freeze in their descent, after they have become large, they form *hail:* if they freeze only partially, they form *sleet. Dew* is nothing but a light rain which falls from a very small height, and is produced by the cooling of the stratum of air in contact with the ground. It differs in no respect from the drops deposited on the outside of a tumbler containing cold water, on a warm, damp day in summer. *Hoar frost* is simply frozen dew.

The particles of water of which clouds are composed are sustained in the air by the cohesion between it and their surfaces, exactly like the small motes that we see floating in the air of a room, in the sunbeams. They cannot be thus sustained when they become larger,

because their surfaces are now much smaller in proportion to their weight. Some suppose that the watery particles of clouds consist of small vesicles filled with air lighter than the atmosphere. This hypothesis is gratuitous and unnecessary: for the particles of dust to which we just alluded, are sustained without being hollow globules; and there is no occasion for any other machinery to support the cloud globules.

The size of rain drops seems to depend chiefly on the rapidity with which the cloud globules are formed: for if these are produced rapidly, many will unite and form large drops; if they are produced slowly, there are not so many to unite,—they are further apart,—and the drops will be smaller. In tropical countries, rain drops are large, because the amount of water in the atmosphere is greater than in other regions, and consequently cloud globules will form more rapidly and abundantly. This explanation is consistent with the fact that rain which forms suddenly generally consists of large drops, while that which forms slowly consists of small drops. Another circumstance which influences the size of rain drops is the height from which they fall: for as they fall they gradually unite. The crystallization of snow is quite similar to that of sal ammoniac, or any gas of that sort, and therefore requires no particular explanation.

Hail is produced by the rain drops meeting in their descent with a current of air cold enough to freeze them. Hence it is apt to occur during rapid and extreme changes of temperature. It is therefore of comparatively rare occurrence, continues only for a short time, and is very limited in extent: and if it sometimes produces injury to crops, it tempers the chilling blast by the great amount of latent heat set free in the act of freezing.

Snow is beneficial in several ways. It not only economizes the supply of water for streams, and greatly tempers the heat and cold of the atmosphere, but it protects roots and seeds from the influence of wintry frosts: for, being a powerful non-conductor of heat, it prevents its escape from the earth, as if it were an immense mantle of wool.* The utility of rains and dews is so obvious that they can hardly escape the observation of a child.

The amount of dew deposited in any place will depend on the rapidity with which the air cools; those bodies which cool rapidly will receive most, and those which cool slowly will receive little, and sometimes none. Thus we may often observe the grass and metallic bodies covered with dew, while the dry dust of the highway is entirely free from it. The grass generally receives a copious supply, because the evaporation from its leaves accelerates its cooling.

* "*He giveth snow like wool.*"—Psalms cxlvii. 16.

There is generally a close relation between the evaporation and the amount of rain which falls in a country. This relation, however, is not constant; for winds may cause the vapors of one country to descend regularly in another, as is the case in many parts of the world. Still, when we take an extensive region, the relation generally holds: thus the heavy rains at the equator correspond with the rapid evaporation; and as the latter diminishes as we move towards the Poles, the annual fall of rain diminishes also. This is very evident from the following statement of the average annual quantity of rain that falls in different latitudes, as given by Humboldt.

	Fall of Rain.
Under the equator, ...	96 inches.
North lat. 19°	80
" 45°	27¾
" 60°	17

The annual average at particular places differs widely from the above general average. At Mahabuleshwar, in the Deccan, 4,200 feet above the sea level, it is 302 inches; at Matawba, in the Island of Guadaloupe, lat. 16° N., 292 in.; at Maranham, in Brazil, 2° S., 281 in.; at Sierra Leone, 8° N., 81 in.; at New York, 41° N., 48 in.; at Madrid, in the same latitude, 10 inches, being smaller than the fall at Petersburg, lat. 60° N., which is 17 inches. Owing probably to the narrowness of the American continent, the fall of rain is much greater than on the Old Continent. Tropical America has an annual fall of 115 inches, while tropical Asia and Africa have only 76. In the north temperate zone of America, it is 37 inches, while in that of the Old Continent it is hardly 32 inches.

It is calculated that if the whole atmosphere were saturated, its total amount of vapor would produce only 5 inches of rain; hence, the vapors of the atmosphere must be frequently renewed in the course of the year. As mountains attract clouds, elevated regions generally receive more rain than lowlands; and as the sea evaporates more freely than the land, more rain generally falls on the coasts than in the interior. To this, however, there are some striking exceptions. Thus, abundance of rain falls in many parts of the interior of South America, while very little falls on the western coast, because the wind generally blows from the east, and the vapors are intercepted before they pass the Andes.

§ VIII.—Clouds.

The watery evaporations which rise from lakes, ponds, rivers, and in fact, from the whole surface of the earth, ascend on account of

their elasticity and lightness, until the air becomes so cold and thin, that they can rise no higher, but are condensed.

The height of the clouds ranges from 50 yards to 4 miles; their average height is calculated to be two miles and a half. Their size is likewise very different. Some clouds have been found, occupying an extent of 20 square miles, and their thickness, in some cases, has been ascertained by travellers who have ascended mountains, to be a thousand feet. Others are thin, and of small dimensions.

Luke Howard, in his Essays on Clouds, divides them, with respect to their forms, into three simple and distinct classes, which he names and defines as follows:—

First, *Cirrus.*—A cloud resembling a lock of hair, or a feather—parallel—flexuous, or diverging fibres, unlimited in their extent and direction.

Second, *Cumulus.*—A cloud which increases from above, in dense, convex, or conical shapes.

Third, *Stratus.*—An extended, continuous, level sheet of cloud, increasing from beneath.

There are two modifications, which appear to be of an intermediate nature; these are—

Fourth, *Cirro-Cumulus.*—A connected system of small, roundish clouds, in close order, or compact.

Fifth, *Cirro-Stratus.*—A horizontal, or slightly inclined sheet, attenuated at its circumference, concave downwards, or undulated. Groups or patches have these characters.

There are two modifications, which exhibit a compound structure, viz.:—

Sixth, *Cumulo-Stratus.*—A cloud in which the structure of the cumulus is mixed with that of the cirro-stratus, or cirro-cumulus; the cumulus flattened at the top, and overhanging its base.

Seventh, *Nimbus.*—A dense cloud spreading out into a crown of cirrus, and passing beneath into a shower.

The above classification is so minute and comprehensive that it must necessarily include most clouds; yet, when we examine these shadowy beings carefully with our own eyes, we see several that do not seem to belong to one of the seven classes more than another; and we are mistaken if, in very tempestuous weather, clouds may not sometimes be seen which cannot well be referred to any of them, without some assistance from the fancy.

The clouds are generally assigned to three atmospheric regions, viz.: the upper, the middle, and the lower; and to these a fourth is sometimes added, viz.: the lowest.

To the upper regions belong the cirrus, otherwise called *curl-cloud* and *gray mare's tail*, which has the least density, but the greatest height, and variety of shape, and direction. This cloud is consid-

ered the first indication of serene and settled weather. It first shows itself in a few fibres, spreading through the atmosphere, and these fibres by degrees increase in length, and new fibres attach themselves to the sides. It is also considered the first indication of wet, after a continuance of dry or clear weather, and appears as a white streak or thread stretched across the sky, the ends lost in the horizon. The cirrus does not last longer than a few hours, and sometimes only a few minutes.

The middle region is the seat of the cumulus, which is generally the most condensed cloud, and moves with the stream of air nearest to the earth. The humidity becomes collected, and shows itself in masses rising conically, and resting on the third region. The appearance, increase, and disappearance of the cumulus in fine weather, are often periodical, and correspondent to the degree of heat. It is properly a day-cloud, and generally forms itself a few hours after sunrise, attains its highest degree in the hottest hours of the afternoon, and decreases and vanishes at sunset. Great masses of cumulus, during high winds, in the quarter of the heavens towards which the wind blows, indicate approaching calm and rain. The cumulus is formed in small specks of cloud, which are white spots at first, and arise from small gatherings of the stratus or evening mist, which, rising in the morning, grows into small masses of cloud, while the rest of the sky becomes clearer. About sunrise these clouds increase in number and size; two or more unite, till a large cloud is formed, which, assuming a *cumulated* and irregularly hemispherical shape, has received the name *cumulus*. Towards evening it separates into small fragments and evaporates, giving place to the stratus or *fall-cloud*, which is the cloud of night. Cumuli which occur during intervals between showers, are more fleecy and variable in form and color. Sometimes they are blackish or deep black, and may at any time increase and obscure the sky, and assume the form of the *twain cloud* or cumulus stratus. The cumulus is the cloud that assumes so many forms of majestic beauty at sunset, and reflects so touchingly the last smile of the departed luminary.

The stratus or *fall-cloud*, includes those fogs and creeping mists which, towards evening, fill the valleys and disappear after sunrise. Frequently, as soon as the sun has set, there is formed a white mist near the ground, which increases in density till midnight, and disappears after sunrise. In winter it becomes more dense, and sometimes lasts several days. The stratus may be distinguished from some varieties of cirro-stratus which resemble it, by the circumstance that the latter wets every object which comes in contact with it. The stratus remains quiet and accumulates layers of vapors and nebulæ, till at last it falls in rain. The horizontal layers some times rise higher than at others.

The phenomenon of the dissolution of clouds into rain, is called *nimbus.* The lower region of the clouds, is that which is nearest the earth. The cloud to which this region belongs, is the nimbus—a cloud which always precedes the fall of rain, snow, or hail. Any of the other clouds may obscure the sky without producing rain, but this scarcely ever does.

In a cumulus that consists of conical and convex aggregations, which increase from a horizontal basis upwards, when the upper or dry region predominates, the cumulus cloud becomes a cirrus; when the lower region prevails it becomes a stratus, which is the accumulation of vapors that, by condensation, are changed into rain drops, and these becoming, by their number and weight, too heavy for the atmosphere to sustain, then Nimbus ascends his throne, and often, with the swift-winged lightning and the thunderbolt for his heralds, slowly unfurls his sable standard, and dashing the sunbeams from his path, pours out his treasures to enrich the earth; and having fulfilled the commands of Deity, majestically retires, bearing in his train the glories of the rainbow.

Among the aqueous meteors there are some which were once considered as miraculous, but which more accurate observation has entirely divested of their supernatural character. Such are showers of blood, which take place when the rain water draws with it a great number of certain red insects, which float in the atmosphere, or swarm on the earth. In May, 1646, there rained at Copenhagen a kind of substance, which was thought to be mineral sulphur; but when the same phenomenon recurred in May, 1804, nothing was discovered but a vegetable substance, in the precipitated matter. The phosphorescence of this substance, at the moment of the rain, which fell in the night, presented an alarming spectacle. Other examples prove, that sulphureous showers are, in general, nothing but the fall of a vegetable powder, taken up by a water-spout or a hurricane. This phenomenon has sometimes lifted and carried to a great distance, sheaves of corn, as well as animals of small size, such as locusts, toads, &c., which, on falling to the earth, have caused alarm and amazement.

The most frightful phenomenon of this description, a shower of fire, has been twice observed by a celebrated naturalist, who declares, that he saw nothing more than rain, very strongly charged with electricity, and which sparkled on touching the ground. The November meteors, also, present the appearance of terrible showers of fire.

§ IX.—Twilight.

The faint light diffused through the atmosphere by the sun, before *its rise,* and after its setting, is occasioned by the atmosphere re-

fracting the rays of the sun, and turning them down on the unilluminated parts of the earth. The morning twilight begins, and the evening twilight ends, when the sun is about 18 degrees below the horizon. When the sun is below that point, the smallest stars are visible to the naked eye, or it is entirely dark. The duration of the twilight is various. In the equatorial regions it lasts, during the equinox, one hour and twelve minutes, and increases as the sun recedes from the equator. At the Poles, where there are six months day, and six months night, the twilight continues about two months; so that a great part of the half year's night is illuminated. It is doubly useful, since it shortens the night, and prevents, at the same time, the injurious effect upon our eyes, of the sudden change from light to darkness. And here we cannot help observing, and being touched by a sense of the unceasing and exquisite tenderness, as well as wisdom of the benevolent Parent of the universe, in thus considering the feeble estate of man, and adapting every part of creation to his most minute requirements, and in blending the charms of beauty with the excellence of utility. The brilliant tints which accompany the rising and setting of the sun arise from this circumstance, that the air, towards night, and in the morning, is considerably condensed, and loaded with a variety of vapors. The very refrangible rays seldom or never reach us. The red and yellow have, alone, inflexibility enough to penetrate through the atmosphere, and to render the vapors and clouds so many movable mirrors. This is the reason, then, why the sun appears so often to be red, morning and evening.

The twilight is shortest at the equator, because the sun rises and sets perpendicularly; and it gradually lengthens as we recede from it, because the sun rises and sets more and more obliquely. The twilights are shortest at the equinoxes, because the sun there moves in a great circle, and therefore has a more rapid diurnal motion; and the twilight afterwards increases, because he moves day by day in a smaller circle, till the solstices, when it again begins to contract.

§ X.—Parhelia and Rainbows.

Parhelia, or mock suns, are phenomena not very common. We see by the side of the sun, often above and below, several images of that luminary, more or less bright. These false suns are sometimes surrounded by a circle of pale light, sometimes adorned by the colors of the rainbow; most commonly, they are not exactly circular, and some have been observed with luminous trains. This meteor has never been seen at the same time in a number of distant places;—it *exhibits a different appearance*, even to spectators who are near to

each other. It is, therefore, an optical illusion. As it snows generally at the very time when a false sun appears, it is supposed, that the circular image of the sun is reflected by the little cylinders of ice of which snow is composed. The rays pass, probably, through an opening between thick clouds, as one lets fall the solar image in a camera obscura. This explanation, however, is not very satisfactory, although no better has ever been given. But there can be no doubt the phenomenon is explicable on ordinary optical principles. It is not confined to the sun: for, mock moons occasionally present themselves. These illusions can take place only when the sun, being distant from the zenith, darts its rays obliquely upon the atmosphere. Accordingly, almost all the parhelia occur either in the morning or in the evening. False suns are often observed in countries where a damp, cold atmosphere prevails. They are frequent phenomena in Greenland.

The rainbow has a near affinity to parhelia, and often accompanies them. Every one knows that this magnificent arch, so wonderfully colored, is the effect of the solar rays refracted and reflected by drops of water suspended in the air. The spectator's eye must always be right between the sun and the rain. We must refer our readers to treatises upon Optics, for a particular explanation of this phenomenon. We shall only remark, that the inner and brighter bow is produced by rays which fall on the upper side of the drops, and are twice refracted and once reflected, while the outer and fainter bow is produced by rays which fall on the lower side of the drops, and are twice reflected as well as twice refracted. It is fainter, because a great deal of the light is lost by every reflection.

What is termed the apotheosis of travellers, is a phenomenon much like that of the rainbow. The Academicians, Bouguer, Godin, and La Condamine, when standing upon the very high mountains of Pambamarca, near Quito, saw their own images in a very light fog, surrounded by several concentric circles, ornamented with the colors of the rainbow. The spectre of Brocken is an optical image of the same kind. It seems to be simply the person's shadow caught on the cloud, and fringed with the circles and colors derived from the diffraction, or deflection, of the extreme rays.

§ XI.—The Mirage and Zodiacal Light.

The mirage, or appearance of objects which are not actually in the horizon, or which exist there in a different situation, is one of the most remarkable of optical illusions. At sea, rocks and sands concealed under the water, appear as if they were raised above the surface.

The Swedish sailors long searched for a pretended magic island, which, from time to time, could be descried between the Isles of Aland and the coasts of Upland. It was a rock elevated by the mirage. At one time, the English saw, with terror, the coasts of Calais and Boulogne apparently approaching the shores of their island. Vessels sometimes present themselves to view as if they were upset, or as if sailing in the clouds. The most celebrated example of this phenomenon, is the Fata Morgana, which is frequently seen in the Straits of Messina, and which the people attribute to the fairy queen, Morgana. The spectator, standing on the Italian coast, perceives, it is said, upon an inclined plain, formed by the waves driven towards the middle of the strait, images of palaces, embattled ramparts, houses, and ships,—at one time turned upside down—at another, confusedly set up again, and presenting the spectacle of towns and landscapes in the air. But Captain Smyth, in his *Memoir on Sicily*, says he never met with a Sicilian who saw anything more than an unusually strong loom, or mirage; and there can be little doubt the real phenomenon has been exaggerated. Of all the effects arising from this cause, that which has been most thoroughly examined, is the optical illusion which the French experienced in the desert, in the vicinity of Egypt; the sandy plain, covered in the distance by a thick vapor, presented the deceptive image of a vast lake, towards which they eagerly hastened, but which appeared to fly before them. All these phenomena are owing to an extraordinary refraction of the rays of light by the lower strata of the atmosphere.

The *zodiacal light* deserves our particular attention. This is a grand phenomenon, which was formerly referred either to the nature of the terrestrial atmosphere, or to the position of the globe with regard to the sun. But it is now certain that it is totally ultramundane, and probably a solar phenomenon. This light presents itself after sunset, under the appearance of a serene, whitish clearness, of a lenticular form, having its base turned towards the sun, and its axis in the zodiac. Mairan has supposed that this light was the atmosphere of the sun: but this explanation was totally rejected by La Place, although his rejection was based on a supposition which may not hold good, viz.: that a solar atmosphere must obey the law of gravitation. We presume it is nothing but a peculiar modification of the ethereal fluid, caused by the intense light and heat of the sun.

§ XII.—Thunder and Lightning.

Among igneous meteors, lightning occupies the first rank. It is known to be the effect of the movements of electricity, the theory

of which must be studied in philosophical treatises. It is developed by the passage of water from the form of steam into that of rain, and hence it is apt to play when heavy clouds form suddenly. It is the effect of changes dependent on heat, and not their cause, as some have represented. It is also largely generated when water assumes the form of steam; and hence it is often seen in incessant play before dry weather, as well as before storms. It is not seen when water changes its form slowly, because the fluid moves in such small quantities as to produce no flash. The electric fluid is quite invisible; it is the suddenly compressed air alone we see. Thunder is simply the noise due to the motions of the electric fluid, and does not differ from the report accompanying the discharge of an electric machine except in being much louder, and consisting of a succession of reports so closely following each other as to produce a continuous peal. The discovery of the identity of lightning and common electricity is due to Dr. Benjamin Franklin.

The number of lives lost every year, owing to ignorance of the laws of electricity, induces us to say a word regarding the course which ought to be pursued during thunder-storms. The practical rules on this subject may be reduced to two brief precepts. 1st. *Keep away from conductors*—such as metals and fluids, which include most conductors, while almost all dry animal and vegetable substances are non-conductors,* such as wool, cotton, wood, glass, and wax, and also brick or stone walls. 2d. *Do not become a prime conductor.* This you will be apt to do whenever you are so situated that the fluid is apt to strike your head first, as when you are on high ground and water is below you. The position of safety is when one is surrounded by conductors so that the fluid is sure to strike one or other of them first, and yet not so near any of them as to be in danger of being struck by the charge which may pass through them. The common practice of standing under a tree during a thunder storm, has cost many persons their lives. With regard to houses, they may always be effectually secured against damage from lightning by the proper application of a sufficient number of proper rods. But we reprobate the opinion of some, who seem to think that one rod, of any sort, anywise placed, is quite sufficient to secure a building of any size. Yet there is not on record a single instance where rods failed, when anything like due care had been used in regard to them.

Thunder is rarely observed in polar regions; it is only a weak decrepitation. As we advance towards the equator, thunder-storms gradually become more violent. The cause of this is obvious from

* It is understood that they have not been burnt: for charcoal is a good *conductor;* and many a house has been destroyed by the fluid being conveyed *down the chimney* by the soot.

what we formerly said of the amount of rain which forms in the various zones.

Storms, notwithstanding the calamities which they sometimes occasion, deserve to be considered as one of the greatest benefits that our Creator has bestowed. They diffuse freshness through the atmosphere when it is in a confined and sultry state—the plants resume their lively green—the flowers raise their drooping heads when their thirst has been quenched by the rain—the crops and fruit, penetrated with new warmth, ripen more rapidly—and the atmosphere that was clogged with impurities, becomes clear and bright.

§ XIII.—The Aurora Borealis.

The aurora borealis, so often described by Ossian, the great Scottish bard, presents a spectacle equally magnificent and astonishing. In these blood-stained and fiery meteors, what poet is there who could not discover the shades of warriors, who, once conquerors of the earth and now imaginary rulers of the air, stoop from the clouds to behold the combats of their posterity. And were not those pale and soft lights the daughters of heroes, who, cut down in the early bloom of their beauty, now floated upon the wings of the wind! We hear their sighs, and the rustling of their resplendent robes, and we see rising towards the zenith, and assembling on every side, the luminous columns of the wandering palace of departed spirits. Such are the glowing fancies of the poet of the North, growing out of the rich hues and varied grandeur of the northern lights, which no familiarity can ever render less brilliant or touching, and which is well calculated, by its ennobling influences, to elevate the mind of the beholder to the sublimity of poetic conceptions.

The aurora borealis, in European countries, uniformly appears in the north, inclining a little to the west. In Greenland, it sometimes appears towards the south. It is observed also in the other hemisphere, but with a feeble lustre, in the direction of the South Pole. Though frequently seen in the temperate zone, it is more common in the Arctic regions, where its light sometimes equals that of the full moon. It generally begins to appear three or four hours after sunset, and is often preceded by a dark cloud nearly resembling the segment of a circle, of which the horizon forms the chord.

This segment, at Upsal, is a deep black; in Lapland it is grayish, or becomes almost invisible. Its circumference soon borders upon a whitish light, which sometimes seems gently to expire. Most frequently, the cloudy segment opens in chinks, or crevices, whence issue streams and rays of light of a yellow, a rose, a purple, or a sea green. A *general movement* agitates all the cloudy and en-

lightened space; rays, becoming more and more bright, shoot across each other, like lightning flashing in the midst of effulgent splendor. Occasionally, all the luminous matter arranges itself in a circle, which has always the magnetic Pole for its centre. Sometimes there is formed in the zenith a luminous crown, which seems to be the central point of all the motions of the luminous matter. After having occupied, for the space of an hour or two, almost the whole expanse of the heavens, the phenomenon contracts itself, at first on the southern side, afterwards on the east and west, and finally it disappears towards the north. The rising sun invariably extinguishes these rival luminaries.

The further we remove from the Pole, the less distinctly do we perceive these different appearances of the aurora; and in France, it generally appears like a light not much elevated above the horizon.

Different explanations have been given of this phenomenon. That of Libes, who attributed it to electricity passing through a mixture of oxygen and nitrogen, is now universally rejected, and even deemed absurd. Everything indicates, however, that it is an electric phenomenon. During its continuance, the magnetic needle is generally disturbed, and sometimes violently agitated; the air is at the same time highly electric. Again, if a long glass tube be partially exhausted of its air, then closely stopped, and applied to the prime conductor of an electric machine, the whole tube becomes luminous, and continues so for some time after it has been removed from the conductor. If after this the tube be drawn through the hand, the light will be remarkably intense, through its whole length; and if it be grasped with both hands, near its extremities, strong flashes of light will dart from one end to the other, for many hours, without the tube being again brought near the conductor. The aurora is, therefore, probably caused by currents of electricity, flowing through the upper regions of the atmosphere, parallel to the meridian.

This meteor is of great use in the northern regions, where it greatly assists in dispelling the gloom of the very long winter night; and it is remarkable that it is most brilliant and frequent exactly in those countries where it is most serviceable.

§ XIV.—The Halo and Ignis Fatuus.

The Halo is a broad circle of nearly uniform diameter, being always about 45°. It appears in a thin cloud, or in a haze, around the sun or moon's disc. Those round the sun are marked with rainbow colors, though fainter; the lunar haloes are generally white, but have sometimes a pale red fringe round the inner edge. Some-

times a second halo is seen, concentric with the former, but much larger, being about 90° in diameter, with fainter colors, and less luminous. These phenomena are attributed to the refraction of light by small prisms of ice, floating in the upper regions of the atmosphere.

The *Corona*, or crown, is a smaller circle than the halo, being scarcely ever more than 12° in diameter, and there are generally three or more concentric rings, differently colored. They are attributed to the deflection of light in passing by the rain globules in the atmosphere. This phenomenon is popularly thought to prognosticate rain; but it is often seen in light fleecy clouds which are the harbingers of fair weather.

St. Elmo's Fire is a faint light which seems to adhere to the points of bodies carried swiftly through the air. It appears on the tops of ship masts, and the points of warlike instruments, when in motion. It seems to be only the escape of electricity, produced by the friction of the air against the moving body. A single flame of this sort was called by the ancients, *Helena*, and when double, *Castor and Pollux*. An individual travelling through the lead mines in Scotland, observed his fingers, switch, and the ears of his horse, ornamented with lights of this description, during wet weather. A Swedish naturalist observed the same during snow.

Animal substances, in a state of putrefaction, sometimes emit phosphorus, which, burning slowly from the contact of the atmosphere, produces light and wandering flames. Such is probably the origin of the *Ignis Fatuus*, which flutters at night over church-yards and fields of battle, and which has given rise to pretended apparitions of spirits in churches, where it is the pernicious custom to accumulate the remains of the dead.

Hydrogen gas is often combined with phosphorus. This mixture not improbably gives rise to those ignes fatui which are said to lead unwary travellers over bogs and marshes, until it leads them to some ditch or pit. The gas is probably disengaged from marshes, or damp and low spots of earth. Ignes fatui, arising from the combustion of this phosphureted hydrogen, are necessarily soon extinguished. But a succession of these fires, will appear to the spectator to be but one single flame, which moves with rapidity from place to place, and flies, or seems to fly, as he approaches it. The air driven on before him, forces the lambent flame to recede.

There are other similar fires, which appear to be immovable when seen from a particular spot. There was one near Rettwick, in Sweden, which, on being examined, was found to proceed from a cavern filled with pyrites and petroleum, the combustion of which had occasioned the phenomenon.

In some places, a continuous current of hydro-phosphoric gas, or

phosphureted hydrogen, rises from the earth. An instance of this kind occurs in the department of Isère, in France. The disengagement of inflammable gas during the summer is so considerable, that we continually see a flame rising seven feet from the surface; and travellers, on first seeing it, think that the whole village of St. Bartholomew is on fire. In other places, carbureted hydrogen issues from the earth, and burns steadily, like ordinary lamp gas, when a flame is applied to it. At the village of Fredonia, in New York, a jet of this kind serves to illuminate the houses. *Naphtha* answers a similar purpose at Baku, on the Caspian Sea; and the sacred fire of the Guebres is nothing but a naphtha spring, kept constantly burning.

§ XV.—Shooting Stars and Fire-balls.

Falling, or shooting stars, are appearances everywhere observed. Some consider them the effect of the combustion of hydrogen gas, more or less sulphureted; for phosphorus is too rapidly inflamed by the contact of the air, to be capable of attaining so great an elevation before burning. But, since the great elevation of most of them has been discovered, this hypothesis has been abandoned: for it is evident they are of ultra-terrestrial origin. The average height of 381, (observed at Geneva and Plachettes, by several astronomers, on the 10th of August, 1838,) was 550 miles; and their average velocity, 240 miles per second. The phenomenon of the celebrated November meteors, which have been so often observed at the same time of the year, indicates that there are certain bodies moving round the sun, besides those generally visible. To this class the November meteors, and many other shooting stars, probably belong, and they owe their brightness to the violent concussion with our atmosphere. The showers of aerolites, or air-stones, that have so frequently fallen,* were, probably, nothing but groups of these, which came within the sphere of the earth's attraction. But some shooting stars cannot well be referred to this class: for, as they shine within the earth's shadow, and far above the atmosphere, they must be luminous; and their velocity is much greater than consists with the supposition of their having planetary motions. We must, therefore, consider them rovers,

* Aerolites are all similar in appearance and composition, however much they may differ in size and shape. They are composed of silica, magnesia, sulphur, metallic iron, nickel, and some traces of chrome. The nickel is wanting in a few specimens. It is remarkable that metallic iron, nickel, and chrome, are never found on the surface of the earth, except in aerolites. Externally they appear black, as if they had been exposed to the heat of a furnace: internally they are of a grayish white. Their specific gravity is from 3½ to 4.

like comets, some of which wander indefinitely far from the sun, and others, perhaps, never cross our path a second time.

Fire-balls, bolides, or *fiery meteors*, present a spectacle more imposing than common shooting stars. They are sometimes seen of an immense size; their light is occasionally red, but oftener of a vivid, dazzling whiteness, like the flame of zinc, mixed with nitre. Yet they seem to differ from the other meteors only in being larger, or perhaps nearer; and the same description will apply to both.

We see those meteors, often in the space of a few seconds, appear to traverse the horizon, blaze like fire-works, then break in pieces, and discharge torrents of flames, with a detonation that shakes the air and the earth, at the moment of their explosion. There are some, which are precipitated like a thunderbolt, break through the roofs of houses, destroy animals, and dismast vessels, and shatter them. At other times they move over the earth like a whirlwind of flame, set fire to trees, and devour, or at least overthrow everything that obstructs their course. But such occurrences are only rare exceptions: for they generally pass without doing any injury.

§ XVI.—Magnetic Phenomena.

When two magnets, or loadstones, are presented to each other, they are mutually attracted at one end, and mutually repelled at the other. When suspended on a pivot, they constantly turn their two points towards the two poles of the world, with some deviation: they communicate, by contact, this power to bars and needles of iron and steel,—to the former momentarily, to the latter permanently. This phenomenon of the direction of magnets was formerly explained, by supposing that the globe itself is a great loadstone, which exercises its magnetic force upon all bodies, more or less sensibly. But since Oersted's discovery of the effect of an electric current upon the needle, new light has arisen on the science of magnetism; and it has been found that the polarity of the needle is caused by a current of electricity, constantly flowing from east to west, this current being caused by the successive heating of the earth by the sun, as it turns on its axis. The needle turns itself always at right angles to the current; and as the various parts of the earth's surface are not heated equally every year, the current slightly changes its direction; and the needle always keeps perpendicular to this direction. The cause of the current turning the needle at right angles to it, is, that there is another current incessantly flowing round the needle; and the one interferes with the other, (like two confluent streams of water which run in different directions,) so that the needle swings round till the action of the *earth's current* on each end is equal. The attrac-

tions and repulsions of magnets, also, are due to their electric currents. By causing an electric current to pass through a coil of copper wire, supported on a cork in water, it immediately becomes a perfect magnet.* The needle always turns to the magnetic poles, one of which is in Boothia Felix, lat. 70° N., long. 97° W., the other is in Victoria Island, lat. 70° S., long. 162° E. These points seem to be those of greatest cold, in each hemisphere: for, magnetic phenomena are ultimately dependent on heat,—a more constant and powerful agent than electricity. The gradual and periodical changes in the direction of the needle indicate a regular cycle in the seasons—a thing often supposed, but not yet satisfactorily shown. The angle that the axis of the magnetic needle makes with the meridian of a place, is termed its *variation*, or *declination*. It is either east or west, and varies in different parts of the globe, at different times of the year, and even at different hours of the day. These diminutions and augmentations vary periodically; and the variations are very considerable. At London, the declination was 11 degrees, 15 minutes east, in 1580; in 1657, the needle pointed directly north; in 1692, it already indicated 6 degrees of western declination; and in 1795, it amounted to 21 degrees. In 1666, there was none at Paris; and in 1795, it amounted to 22 degrees, 30 minutes, towards the west. We find upon the globe a number of spots in which there is no declination; but these belts without declination change their position every year. Hence, we are obliged to revise magnetic maps every 10 or 12 years.

The diurnal oscillations are also considerable. The greatest is in central Europe, where it is 14 minutes. At the equator, they are only 3 or 4 minutes, but they occur with great regularity. The needle is generally at its mean position at 8 A. M., and is at its greatest westerly deviation at 1 or 2 P. M.

The *inclination* or *dip* of the needle consists in its always assuming a position parallel to that of the magnetic axis of the earth, or the line joining the two magnetic poles. Under the equator it supports itself nearly in a horizontal position. The circle where it does so exactly, is partly south and partly north of the terrestrial equator, and termed the *magnetic equator*. It, of course, deviates more and more from the horizontal position, as it approaches the magnetic poles; where it assumes a vertical position, and of course becomes useless to the mariner. All the phenomena can be imitated by taking a hollow sphere, with a very powerful magnet in its axis, the effect of the terrestrial current, of which we have

* The celebrated De la Rive invented a contrivance by which this may be shown instantaneously: it is sold by mathematical instrument-makers under the name of *De la Rive's Ring*.

spoken, being to make the earth in fact a huge magnet. The force with which the needle is moved varies greatly in different parts of the world, and is not constant at any place. The position of the points of maximum force or intensity is very irregular and inexplicable. One is at present south-west of Hudson's Bay, and another in the South Atlantic in lat. 20° S. and long. 36° W.

Gay Lussac proved by a balloon excursion that at an elevation of 21,600 feet, the declination and intensity were the same as upon the earth's surface.

The circle which coincides with the vertical plane, passing through the direction of the needle, is called the *magnetic meridian*. The magnetic equator deviates in the Pacific Ocean from the terrestrial equator, about 12°, and this is at present their greatest deviation. Lines in which the declination is equal are called lines of equal variation; and those where the dip is equal are called lines of equal dip. Magnetic storms sometimes occur, when the needle is violently agitated. One of these happened in 1841, and seems to have been general all over the world. These commotions are never of long duration. They are probably owing to changes which take place deep within the earth.

PART II.

ANEMOGRAPHY, OR DESCRIPTION OF THE WINDS.

§ I.—Classification of Winds.

The atmosphere experiences agitations which displace its particles in every direction, and which all depend on a single cause, the interruption of its equilibrium, the restoration of which necessarily takes place in conformity with the laws common to all fluids. A change in the temperature of a column of air, the transformation of a portion of the atmospheric gases into water, their congelation, in a word, whatever causes a vacuum, a condensation, or an expansion, and consequently destroys the equilibrium existing among the different parts of the atmosphere, necessarily produces the rapid displacement of a mass of air, that is to say, a *wind*. The winds

may be classified on various principles. Their velocity being the circumstance most palpable to our senses, has given rise to the following classification; the velocities given being determined by Smeaton, the celebrated engineer, from many facts and experiments.

Appellation.	Velocity per Hour.
Very light,	1 mile.
Gentle,	4 miles to 5
Brisk gale,	10 " " 15
Very brisk,	20 " " 25
High wind,	30 " " 35
Very high,	about 40 "
A storm,	" 50 "
A great storm,	" 60 "
A hurricane,	" 80 "
A violent hurricane,	" 100 "

The direction of winds is not designated like that of marine currents by the point of the compass to which they tend, but by the point from which they come; thus a northerly wind is directly contrary to a northerly current.

With regard to duration, winds are distinguished as *constant* and *variable;* with regard to extent,—as *general* and *partial.* Two general and constant movements exist in the atmosphere; the one prevails chiefly in the torrid zone, and carries the air westward with respect to the earth, and in a direction conformable to that of the general movement of the ocean; the other, which is principally felt in the other zones, carries the polar air towards the equator, and by this means produces two polar currents or effluxes similar to those already pointed out in the ocean, the causes being in both cases precisely the same.

§ II.—Constant, or Trade-Winds.

We shall first consider the trade-winds, or those constant east winds which blow within 28° of the equator. The primary cause of the trade-winds is the expansion which the air undergoes from the action of heat; for the sun must evidently by its heat rarefy the air within the tropics much more than it does that beyond them. The equilibrium of the atmosphere being thus disturbed, the denser and heavier air flows in from the colder regions to restore it. The currents have an apparent westerly motion precisely like the marine currents; and as the same explanation applies to both phenomena, we need not give any particular explanation of that now under discussion, as it would be merely a repetition of what we formerly said.

The trade-winds are divided into *southern*, or those that blow south of the equator, and *northern*, or those that blow north of the equator. The former extends from about 3° N. lat. to 22° S. in the Atlantic, 24° in the Pacific, and 27° in the Indian Ocean. Towards its southern border, it blows from the south-east; hence some call it the *south-east* trade-wind. As it approaches its northern limit, it becomes more and more easterly. The northern trade-wind extends from about 9° N. to 28° N. in the Atlantic, and 25° N. in the Pacific. Its direction is at first north-east, whence it is sometimes termed the *north-east* trades, and it becomes more and more easterly as it approaches its southern limit. The trade-winds blow regularly out at sea: for near land, mountain chains, and the great heat produced by the strong reflection of the sun's rays from the land, often interfere with their direction. On the open ocean they generally blow steadily; so that it has been said if there were a strait at the Isthmus of Panama, a voyage to China could be performed much quicker by sailing westward across the Pacific, than by sailing eastward against these winds. In sailing from Acapulco to the Philippines, the Spaniards simply allowed themselves to be carried westward by the trades and the equatorial current, to the place of their destination: and this is said to be the reason why they navigated the Pacific so long without discovering any of those islands near which they must so often have sailed.

During the day, and in summer generally, the land reflects much more heat than the water, while the latter frequently gives out more heat during the night, and in winter. This is the reason why the breadth of the trades is greater in the Atlantic and Indian Oceans, than in the Pacific, whose wide waters absorb an immense amount of solar heat, part only of which is returned by radiation, the rest becoming latent in the water evaporated, and passing off in the equatorial oceanic current and its branches. For the same reason, the course of the trades in the eastern part of the Pacific is more uniform than in the Atlantic. On the coast of Africa, for example, from the equator to 10° N. lat., and from about 10° to 25° W. long., south-westerly winds are the most prevalent. The breadth of these winds becomes gradually greater as we approach the coast; and hence we may conclude they are nothing but the trades turned in a north-easterly direction by the extreme rarefaction of the air produced above the burning sands of the Sahara and the arid Kong Mountains. But as the heat of these regions is sometimes greatly moderated by heavy falls of rain, we need not be surprised to learn that that part of the South Atlantic where these winds prevail is very subject to heavy squalls and thunder-storms, with intervening calms.

As the northern and southern trades approach, the one in a great measure neutralizes the other, and calms prevail over a zone of 5°

or 6° in breadth. This is termed *the calms*, or *variables*; and in the neighborhood of land it is subject occasionally to squalls, heavy rains, and thunder-storms, which generally pass off very rapidly. Owing to the prevalence of land in the northern hemisphere, its centre, which may be considered the boundary line of the two trade-winds, is north of the equator. It runs from about 3° to 12° N. lat. When the sun is vertical north of the equator, the regions immediately under it have the air most rarefied. Hence, as he advances from the southern to the northern tropic, the centre of the variables moves from about the 3° to the 12° of N. lat. When the sun turns south it moves the other way, the outer limits of the trades having a corresponding simultaneous motion. The variables seldom extend south of the equator, or north of lat. 13° N. But their limits vary from year to year. The same is true of the trade-winds. Sometimes the northern extend to 32° N. lat. during the summer solstice. In other years, they do not blow beyond 30° N. The southern limits of the southern trade varies in the same way, though somewhat less extensively. Around the external limits of the trades, short calms occur; but they are generally soon succeeded by squalls.

When the polar currents have reached the equatorial regions, they become rarefied in their turn, ascend into the upper regions, and flow back towards the Poles *above* the usual trade-winds. These currents are sometimes called the *upper trade-winds*. They begin generally about 2½ miles above the sea level. Their direction is evident from that of the clouds, and sometimes the volcanic ashes which they convey; and they are felt on high mountains, like the Peak of Teneriffe. Their general direction is easterly, because their easterly motion is more rapid than that of the successive places to which they come. By the time they have got beyond the limits of the lower trade-winds, they are sufficiently cooled to displace the polar current, which now flows above, while that from the equator flows below. In the northern hemisphere, their course is north-easterly, and in the southern hemisphere, south-easterly. They may be called the *westerly* trade-winds, in contradistinction from the tropical or easterly. The particular point at which the upper and lower currents will exchange places, depends partly on the position of the sun; and hence over a great part of the north temperate zone, north-easterly winds blow generally at certain times of the year, and south-westerly winds for most of the time. In the south temperate zone, a south-easterly wind blows, instead of the usual north-westerly.

We can now easily understand why a voyage from the United States to northern Europe, is, on an average, ten days shorter than one in the contrary direction. We can also understand the reason for the course adopted by vessels from northern Europe on voyages *to the West Indies*. On the outward passage, they sail down to the

Madeiras, to catch the easterly trades; on the return passage, they sail north-west towards the Bermudas, till they fall in with the westerly trades.

The particular place where the northerly and southerly currents exchange position, depends not only on the sun's position, but on particular local circumstances; hence it is not at the same distance from the equator in every place, nor is it always uniform at one place every year. The zone within these limits is subject to sudden variations in the direction of the wind, producing great and sudden changes of temperature; it extends from about the 35° to the 45° of latitude. In the northern hemisphere, the westerly trades prevail up to 60° N.; in the southern hemisphere, they do not seem to extend much beyond 55° S. The course of the winds beyond these limits is not as yet well known.

§ III.—Variable Winds.

The inequalities of the earth's surface, and the diversity of its soils, have, no doubt, a powerful influence upon the direction of the winds. At one place, mountains, covered with perpetual snow, arise, and prevent the air from undergoing the same expansion as in the valleys: at another, burning sands produce an unusual degree of rarefaction. At a third, we observe large basins of water, surrounded and irregularly indented by land. The air must, therefore, suffer relative and partial condensations and expansions. Hence the sea breeze, the land breeze, and the mountain breeze. These changes, too, will occur differently, in summer and winter, during the day, and during the night. Hence the morning and the evening breezes, whose refreshing breath reanimates us, in the warm season.

The tropical islands, notwithstanding their small circumference, have the air above them so much rarefied during the day-time, as to cause the general east wind to blow from all points of the compass, towards the central summit of the island, forming the sea breeze, which generally springs up in the forenoon. From its refreshing and reviving influences, it is termed, in many of the West India Islands, *the doctor.* When night arrives, the sea radiates more heat than the land; hence, the air flows back again from the summit, towards the sea, in every direction, constituting the land breeze. These land and sea breezes are most prevalent in the torrid zone; but they are, by no means, confined to it.

Chains of mountains may arrest winds in the lower regions of the atmosphere, or turn them from their direct path, and sometimes give them more impetuosity, as marine currents acquire greater force in the neighborhood of straits and promontories. Such violent move-

ments of the air, when arrested by an obstacle, have given particular notoriety to Cape Horn and the Cape of Good Hope, and many others. When a strong and sudden rarefaction of the air takes place, there is an outward current in all directions, generally followed by a strong current in the opposite direction. Of the former nature is the wind that blows from the deserts of Africa and Arabia, termed *simoom* and *samiel* in Arabia and Turkey; *chamsin* in Syria and Egypt; and *harmattan* in Western Africa. This wind was formerly supposed to be rendered pestilential by an intermixture of poisonous gases: but it seems to be entirely free from anything of that kind. Its bad effects are attributable to its extreme heat and dryness, and to the fine dust and sand mechanically sustained by it. In crossing the Mediterranean, it becomes surcharged with moisture, and forms the *sirocco* of the Italians, and the *solano* of the Spaniards, which produces languor and febrile irritation by its heat, and by stopping the perspiration.

§ IV.—Hurricanes.

Hurricanes are produced by anything which causes an extreme degree of rarefaction, or an extensive partial vacuum in the air. They may, therefore, result from intense heat, or from the sudden formation of a great quantity of rain. Anything, in short, which rapidly and extensively deranges the equilibrium of the atmosphere, will cause a hurricane, from the rush of air from all quarters, to restore the equilibrium. The nature of a hurricane may be understood by observing the whirlwinds caused by a strong fire in a clearing among the woods. The hurricanes of temperate regions are not in any way to be compared with those of the torrid zone. Generally speaking, the former are nothing more than slight whirlwinds. But in a tropical hurricane, all the elements sometimes seem to have combined and armed themselves for the destruction of nature. The lightnings cross each other, the thunder roars without interval, rain falls down in torrents. The velocity of the wind becomes excessive. Forests, houses, every object is swept before it, that is found in its path.

Hurricanes begin in very different ways: sometimes a little black cloud appears on the summit of a mountain; at the instant when it seems to settle on the peak, it rushes down the declivity, unrolls itself, dilates, and covers the whole horizon. At other times, the tempest advances in the shape of a fire-colored cloud, showing itself suddenly, in a calm and serene sky.

As the air rushes in from every quarter, it acquires a whirling motion, so that it describes a spiral. Mr. Espy, in opposition to Redfield and Reid, maintains that the currents always move in a

straight line towards a centre. We presume this may be true to a certain extent at a distance from the centre of large storms, and true to a greater extent of small storms; but that strong currents can long move in straight lines without acquiring a spiral or gyratory motion, is at variance with all that we otherwise know of the motions of elastic fluids, except in the single case where all the currents are equally powerful at every point of the circumference, a thing which must be of comparatively rare occurrence. The common whirlwinds are familiar instances of the gyratory motions; and the extensive researches of Redfield, confirmed by the immense number of details collected by Col. Reid, prove that the motion of hurricane currents is similar. Nothing is more common than for navigators to find, on comparing logs, that the one had a strong westerly wind, while another had a strong wind in the opposite direction, not more than 50 miles south, and a third, not more than 100 miles further south, had no storm whatever. The motion of the wind gradually becomes swifter towards the centre, or axis of the storm; but on the very axis there is a calm. Hence, there is first a strong wind in one direction, then a short calm, followed by a violent wind in the opposite direction. The diameter of the calm ranges from 5 to 30 miles; the commotion never extends higher than 5 miles perpendicular height, and sometimes only one mile. Sometimes the area covered by the tempest is 1,000 miles in diameter, but generally it does not exceed 200. The axis of a hurricane moves with a velocity varying from 15 to 40 miles, the average being about 20 miles an hour. The friction of the earth causes the axis to lean forward, and leads to an ascent of the lower and warmer air, which, mixing with the upper cold air, produces torrents of rain and electric explosions.

The two principal regions of hurricanes are the West Atlantic and the Indian Oceans. The Atlantic hurricanes begin generally east of the Leeward Islands, in lat. 18° N. They move north-west till they are off the coast of Florida, about 25° or 30° N., and then pass north-east along the American coast and across the Atlantic. They generally terminate south-east of Newfoundland; but sometimes they reach the continent of Europe. They describe a curve, nearly parabolic, with the focus generally a little south of the Bermudas. The circular motion of the wind, considered from the axis, is always *from right to left;* and such is the direction of all hurricanes in the northern hemisphere. A knowledge of this fact will enable the navigator to sail away from the strength of the tempest. If it blow from the east, the axis is to the south, and he should steer north; if from the west, the case is reversed. If it blow from the north, the axis is to the east, and he should sail to the west, and so on.

In the Indian Ocean, the course both of the axis and the rotating

currents is reversed. Here the hurricanes generally begin north-east of Madagascar, about long. 80° E., and lat. 10° S., and the axis moves at first south-west, towards Madagascar, and then south-east, in the direction of St. Paul's Island, describing a parabola, of which the Isle of France is near the focus. The revolving of the current is here *from left to right;* and a vessel would, of course, sail in a direction opposite to that required in the Atlantic hurricanes. The storms of the southern hemisphere generally rotate in the same direction.

Hurricanes occur when the sun is most powerful on that side of the equator—those of the Atlantic from June to October, and those of the Indian Ocean from December to April.

The *typhoons* are simply violent hurricanes, which prevail in the China Sea, and eastward to 135° E. long., their range becoming wider as we proceed eastward. They rotate like the Atlantic hurricanes.

In consequence of the centrifugal force of the air in a hurricane, its downward pressure is much diminished; and this is indicated by a rapid falling of the mercury in the barometer. The air is generally disturbed for some hours before it begins to blow with any great degree of violence; and hence, the wary mariner has time to prepare for the coming storm. The barometer has thus been repeatedly the means of saving vessels, and the lives of all on board. When the force of the storm is spent, the barometer begins to rise, and then the navigator may gradually unfurl his sails.

Although hurricanes follow a certain direction, they do not move with a uniform velocity in every part of their course; and sometimes they have been known to stop altogether for awhile, and then resume their course. Sometimes two hurricanes are simultaneous, and move in parallel directions; at other times their courses are inclined, and they meet, when a tremendous commotion ensues. A hurricane has also been known to be divided into two by a promontory.

The diminished pressure of the air occasioned by a hurricane, sometimes leads to the formation of a huge swell on the ocean. This is, of course, highest in the axis, where it is often two feet in height. This wave moves along with the tempest, and sometimes rolls against the land, whose resistance raises it to such a height that it resembles an earthquake wave, and does great damage to life and property.

Tornadoes differ from ordinary hurricanes only in being less extensive in their range, and more rapid in their motion. Common *whirlwinds* are only tornadoes on a small scale.

§ V.—Water Spouts.

Water spouts are distinguished as *terrestrial* and *marine*. The latter are found to occur in the following manner. Under a dense cloud, the sea becomes agitated with violent commotions; the waves dart rapidly towards the centre of the agitated mass of water, on arriving at which they rise, whirling round in a spiral direction towards the cloud. This conical ascending column is met by another descending column which moves towards the water and joins it. In many cases, the marine column is from 50 to 80 fathoms in diameter near its base. Both columns, however, diminish towards the middle where they often unite; so that here they do not extend more than 3 or 4 feet in diameter. The entire column presents itself in the shape of two cones joined at their apices. This column glides over the sea, sometimes without any wind being felt. Indeed, several have been seen gliding at the same moment in opposite directions. When the cloud and the marine base of the water spout move with unequal velocities, the lower cone is often seen to incline sideways, or even to bend, and finally to break in pieces. A noise is then heard, like that of a cataract falling into a deep valley. Lightning frequently issues from the centre of a water spout, or from the sides, particularly when it breaks; but no thunder is heard.

This phenomenon is explained in the following manner. Two winds of different temperatures meet; a vortex ensues. Their vapors are condensed and turned round with great velocity, so that they assume a conical form. This rotation impresses all the particles of the cloud with a centrifugal force: they are driven towards the exterior surface; a vacuum is produced within about the axis of the cone; water, or any other body lying beneath this vacuum, is carried into it by the effect of gravity, striving to re-establish an equilibrium.

§ VI.—Monsoons or Periodical Winds.

These winds prevail chiefly in the Indian Ocean. From the 10th degree of south latitude to the Tropic of Capricorn, and beyond it, the general east or south-east trade-wind prevails over all the Indian Ocean,—sometimes, in summer, extending as far as the 2d and 3d degrees of south latitude. On this side of the 10th degree, we first meet with the monsoons, or periodical half-yearly winds: from April to October, a strong south-west wind prevails, accompanied with storms and rain, while a dry and pleasant north-east wind prevails during the other 6 months. South of the 10th parallel, the trade-winds blow regularly.

tions and repulsions of magnets, also, are due to their electric currents. By causing an electric current to pass through a coil of copper wire, supported on a cork in water, it immediately becomes a perfect magnet.* The needle always turns to the magnetic poles, one of which is in Boothia Felix, lat. 70° N., long. 97° W., the other is in Victoria Island, lat. 70° S., long. 162° E. These points seem to be those of greatest cold, in each hemisphere: for, magnetic phenomena are ultimately dependent on heat,—a more constant and powerful agent than electricity. The gradual and periodical changes in the direction of the needle indicate a regular cycle in the seasons—a thing often supposed, but not yet satisfactorily shown. The angle that the axis of the magnetic needle makes with the meridian of a place, is termed its *variation*, or *declination*. It is either east or west, and varies in different parts of the globe, at different times of the year, and even at different hours of the day. These diminutions and augmentations vary periodically; and the variations are very considerable. At London, the declination was 11 degrees, 15 minutes east, in 1580; in 1657, the needle pointed directly north; in 1692, it already indicated 6 degrees of western declination; and in 1795, it amounted to 21 degrees. In 1666, there was none at Paris; and in 1795, it amounted to 22 degrees, 30 minutes, towards the west. We find upon the globe a number of spots in which there is no declination; but these belts without declination change their position every year. Hence, we are obliged to revise magnetic maps every 10 or 12 years.

The diurnal oscillations are also considerable. The greatest is in central Europe, where it is 14 minutes. At the equator, they are only 3 or 4 minutes, but they occur with great regularity. The needle is generally at its mean position at 8 A. M., and is at its greatest westerly deviation at 1 or 2 P. M.

The *inclination* or *dip* of the needle consists in its always assuming a position parallel to that of the magnetic axis of the earth, or the line joining the two magnetic poles. Under the equator it supports itself nearly in a horizontal position. The circle where it does so exactly, is partly south and partly north of the terrestrial equator, and termed the *magnetic equator*. It, of course, deviates more and more from the horizontal position, as it approaches the magnetic poles; where it assumes a vertical position, and of course becomes useless to the mariner. All the phenomena can be imitated by taking a hollow sphere, with a very powerful magnet in its axis, the effect of the terrestrial current, of which we have

* The celebrated De la Rive invented a contrivance by which this may be shown instantaneously: it is sold by mathematical instrument-makers under the name of *De la Rive's Ring*.

spoken, being to make the earth in fact a huge magnet. The force with which the needle is moved varies greatly in different parts of the world, and is not constant at any place. The position of the points of maximum force or intensity is very irregular and inexplicable. One is at present south-west of Hudson's Bay, and another in the South Atlantic in lat. 20° S. and long. 36° W.

Gay Lussac proved by a balloon excursion that at an elevation of 21,600 feet, the declination and intensity were the same as upon the earth's surface.

The circle which coincides with the vertical plane, passing through the direction of the needle, is called the *magnetic meridian*. The magnetic equator deviates in the Pacific Ocean from the terrestrial equator, about 12°, and this is at present their greatest deviation. Lines in which the declination is equal are called lines of equal variation; and those where the dip is equal are called lines of equal dip. Magnetic storms sometimes occur, when the needle is violently agitated. One of these happened in 1841, and seems to have been general all over the world. These commotions are never of long duration. They are probably owing to changes which take place deep within the earth.

PART II.

ANEMOGRAPHY, OR DESCRIPTION OF THE WINDS.

§ I.—Classification of Winds.

The atmosphere experiences agitations which displace its particles in every direction, and which all depend on a single cause, the interruption of its equilibrium, the restoration of which necessarily takes place in conformity with the laws common to all fluids. A change in the temperature of a column of air, the transformation of a portion of the atmospheric gases into water, their congelation, in a word, whatever causes a vacuum, a condensation, or an expansion, and consequently destroys the equilibrium existing among the different parts of the atmosphere, necessarily produces the rapid displacement of a mass of air, that is to say, a *wind*. The winds

may be classified on various principles. Their velocity being the circumstance most palpable to our senses, has given rise to the following classification; the velocities given being determined by Smeaton, the celebrated engineer, from many facts and experiments.

Appellation.	Velocity per Hour.
Very light, ...	1 mile.
Gentle, ...	4 miles to 5
Brisk gale, ...	10 " " 15
Very brisk, ...	20 " " 25
High wind, ...	30 " " 35
Very high, ...	about 40 "
A storm, ...	" 50 "
A great storm, ...	" 60 "
A hurricane, ...	" 80 "
A violent hurricane, . . .	" 100 "

The direction of winds is not designated like that of marine currents by the point of the compass to which they tend, but by the point from which they come; thus a northerly wind is directly contrary to a northerly current.

With regard to duration, winds are distinguished as *constant* and *variable;* with regard to extent,—as *general* and *partial.* Two general and constant movements exist in the atmosphere; the one prevails chiefly in the torrid zone, and carries the air westward with respect to the earth, and in a direction conformable to that of the general movement of the ocean; the other, which is principally felt in the other zones, carries the polar air towards the equator, and by this means produces two polar currents or effluxes similar to those already pointed out in the ocean, the causes being in both cases precisely the same.

§ II.—Constant, or Trade-Winds.

We shall first consider the trade-winds, or those constant east winds which blow within 28° of the equator. The primary cause of the trade-winds is the expansion which the air undergoes from the action of heat; for the sun must evidently by its heat rarefy the air within the tropics much more than it does that beyond them. The equilibrium of the atmosphere being thus disturbed, the denser and heavier air flows in from the colder regions to restore it. The currents have an apparent westerly motion precisely like the marine currents; and as the same explanation applies to both phenomena, we need not give any particular explanation of that now under discussion, as it would be merely a repetition of what we formerly said.

The trade-winds are divided into *southern*, or those that blow south of the equator, and *northern*, or those that blow north of the equator. The former extends from about 3° N. lat. to 22° S. in the Atlantic, 24° in the Pacific, and 27° in the Indian Ocean. Towards its southern border, it blows from the south-east; hence some call it the *south-east* trade-wind. As it approaches its northern limit, it becomes more and more easterly. The northern trade-wind extends from about 9° N. to 28° N. in the Atlantic, and 25° N. in the Pacific. Its direction is at first north-east, whence it is sometimes termed the *north-east* trades, and it becomes more and more easterly as it approaches its southern limit. The trade-winds blow regularly out at sea: for near land, mountain chains, and the great heat produced by the strong reflection of the sun's rays from the land, often interfere with their direction. On the open ocean they generally blow steadily; so that it has been said if there were a strait at the Isthmus of Panama, a voyage to China could be performed much quicker by sailing westward across the Pacific, than by sailing eastward against these winds. In sailing from Acapulco to the Philippines, the Spaniards simply allowed themselves to be carried westward by the trades and the equatorial current, to the place of their destination: and this is said to be the reason why they navigated the Pacific so long without discovering any of those islands near which they must so often have sailed.

During the day, and in summer generally, the land reflects much more heat than the water, while the latter frequently gives out more heat during the night, and in winter. This is the reason why the breadth of the trades is greater in the Atlantic and Indian Oceans, than in the Pacific, whose wide waters absorb an immense amount of solar heat, part only of which is returned by radiation, the rest becoming latent in the water evaporated, and passing off in the equatorial oceanic current and its branches. For the same reason, the course of the trades in the eastern part of the Pacific is more uniform than in the Atlantic. On the coast of Africa, for example, from the equator to 10° N. lat., and from about 10° to 25° W. long., south-westerly winds are the most prevalent. The breadth of these winds becomes gradually greater as we approach the coast; and hence we may conclude they are nothing but the trades turned in a north-easterly direction by the extreme rarefaction of the air produced above the burning sands of the Sahara and the arid Kong Mountains. But as the heat of these regions is sometimes greatly moderated by heavy falls of rain, we need not be surprised to learn that that part of the South Atlantic where these winds prevail is very subject to heavy squalls and thunder-storms, with intervening calms.

As the northern and southern trades approach, the one in a great measure neutralizes the other, and calms prevail over a zone of 5°

or 6° in breadth. This is termed *the calms*, or *variables;* and in the neighborhood of land it is subject occasionally to squalls, heavy rains, and thunder-storms, which generally pass off very rapidly. Owing to the prevalence of land in the northern hemisphere, its centre, which may be considered the boundary line of the two trade-winds, is north of the equator. It runs from about 3° to 12° N. lat. When the sun is vertical north of the equator, the regions immediately under it have the air most rarefied. Hence, as he advances from the southern to the northern tropic, the centre of the variables moves from about the 3° to the 12° of N. lat. When the sun turns south it moves the other way, the outer limits of the trades having a corresponding simultaneous motion. The variables seldom extend south of the equator, or north of lat. 13° N. But their limits vary from year to year. The same is true of the trade-winds. Sometimes the northern extend to 32° N. lat. during the summer solstice. In other years, they do not blow beyond 30° N. The southern limits of the southern trade varies in the same way, though somewhat less extensively. Around the external limits of the trades, short calms occur; but they are generally soon succeeded by squalls.

When the polar currents have reached the equatorial regions, they become rarefied in their turn, ascend into the upper regions, and flow back towards the Poles *above* the usual trade-winds. These currents are sometimes called the *upper trade-winds*. They begin generally about 2½ miles above the sea level. Their direction is evident from that of the clouds, and sometimes the volcanic ashes which they convey; and they are felt on high mountains, like the Peak of Teneriffe. Their general direction is easterly, because their easterly motion is more rapid than that of the successive places to which they come. By the time they have got beyond the limits of the lower trade-winds, they are sufficiently cooled to displace the polar current, which now flows above, while that from the equator flows below. In the northern hemisphere, their course is north-easterly, and in the southern hemisphere, south-easterly. They may be called the *westerly* trade-winds, in contradistinction from the tropical or easterly. The particular point at which the upper and lower currents will exchange places, depends partly on the position of the sun; and hence over a great part of the north temperate zone, north-easterly winds blow generally at certain times of the year, and south-westerly winds for most of the time. In the south temperate zone, a south-easterly wind blows, instead of the usual north-westerly.

We can now easily understand why a voyage from the United States to northern Europe, is, on an average, ten days shorter than one in the contrary direction. We can also understand the reason for the course adopted by vessels from northern Europe on voyages to the West Indies. On the outward passage, they sail down to the

Madeiras, to catch the easterly trades; on the return passage, they sail north-west towards the Bermudas, till they fall in with the westerly trades.

The particular place where the northerly and southerly currents exchange position, depends not only on the sun's position, but on particular local circumstances; hence it is not at the same distance from the equator in every place, nor is it always uniform at one place every year. The zone within these limits is subject to sudden variations in the direction of the wind, producing great and sudden changes of temperature; it extends from about the 35° to the 45° of latitude. In the northern hemisphere, the westerly trades prevail up to 60° N.; in the southern hemisphere, they do not seem to extend much beyond 55° S. The course of the winds beyond these limits is not as yet well known.

§ III.—Variable Winds.

The inequalities of the earth's surface, and the diversity of its soils, have, no doubt, a powerful influence upon the direction of the winds. At one place, mountains, covered with perpetual snow, arise, and prevent the air from undergoing the same expansion as in the valleys: at another, burning sands produce an unusual degree of rarefaction. At a third, we observe large basins of water, surrounded and irregularly indented by land. The air must, therefore, suffer relative and partial condensations and expansions. Hence the sea breeze, the land breeze, and the mountain breeze. These changes, too, will occur differently, in summer and winter, during the day, and during the night. Hence the morning and the evening breezes, whose refreshing breath reanimates us, in the warm season.

The tropical islands, notwithstanding their small circumference, have the air above them so much rarefied during the day-time, as to cause the general east wind to blow from all points of the compass, towards the central summit of the island, forming the sea breeze, which generally springs up in the forenoon. From its refreshing and reviving influences, it is termed, in many of the West India Islands, *the doctor*. When night arrives, the sea radiates more heat than the land; hence, the air flows back again from the summit, towards the sea, in every direction, constituting the land breeze. These land and sea breezes are most prevalent in the torrid zone; but they are, by no means, confined to it.

Chains of mountains may arrest winds in the lower regions of the atmosphere, or turn them from their direct path, and sometimes give them more impetuosity, as marine currents acquire greater force in the neighborhood of straits and promontories. Such violent move-

ments of the air, when arrested by an obstacle, have given particular notoriety to Cape Horn and the Cape of Good Hope, and many others. When a strong and sudden rarefaction of the air takes place, there is an outward current in all directions, generally followed by a strong current in the opposite direction. Of the former nature is the wind that blows from the deserts of Africa and Arabia, termed *simoom* and *samiel* in Arabia and Turkey; *chamsin* in Syria and Egypt; and *harmattan* in Western Africa. This wind was formerly supposed to be rendered pestilential by an intermixture of poisonous gases: but it seems to be entirely free from anything of that kind. Its bad effects are attributable to its extreme heat and dryness, and to the fine dust and sand mechanically sustained by it. In crossing the Mediterranean, it becomes surcharged with moisture, and forms the *sirocco* of the Italians, and the *solano* of the Spaniards, which produces languor and febrile irritation by its heat, and by stopping the perspiration.

§ IV.—Hurricanes.

Hurricanes are produced by anything which causes an extreme degree of rarefaction, or an extensive partial vacuum in the air. They may, therefore, result from intense heat, or from the sudden formation of a great quantity of rain. Anything, in short, which rapidly and extensively deranges the equilibrium of the atmosphere, will cause a hurricane, from the rush of air from all quarters, to restore the equilibrium. The nature of a hurricane may be understood by observing the whirlwinds caused by a strong fire in a clearing among the woods. The hurricanes of temperate regions are not in any way to be compared with those of the torrid zone. Generally speaking, the former are nothing more than slight whirlwinds. But in a tropical hurricane, all the elements sometimes seem to have combined and armed themselves for the destruction of nature. The lightnings cross each other, the thunder roars without interval, rain falls down in torrents. The velocity of the wind becomes excessive. Forests, houses, every object is swept before it, that is found in its path.

Hurricanes begin in very different ways: sometimes a little black cloud appears on the summit of a mountain; at the instant when it seems to settle on the peak, it rushes down the declivity, unrolls itself, dilates, and covers the whole horizon. At other times, the tempest advances in the shape of a fire-colored cloud, showing itself suddenly, in a calm and serene sky.

As the air rushes in from every quarter, it acquires a whirling motion, so that it describes a spiral. Mr. Espy, in opposition to *Redfield* and *Reid*, maintains that the currents always move in a

straight line towards a centre. We presume this may be true to a certain extent at a distance from the centre of large storms, and true to a greater extent of small storms; but that strong currents can long move in straight lines without acquiring a spiral or gyratory motion, is at variance with all that we otherwise know of the motions of elastic fluids, except in the single case where all the currents are equally powerful at every point of the circumference, a thing which must be of comparatively rare occurrence. The common whirlwinds are familiar instances of the gyratory motions; and the extensive researches of Redfield, confirmed by the immense number of details collected by Col. Reid, prove that the motion of hurricane currents is similar. Nothing is more common than for navigators to find, on comparing logs, that the one had a strong westerly wind, while another had a strong wind in the opposite direction, not more than 50 miles south, and a third, not more than 100 miles further south, had no storm whatever. The motion of the wind gradually becomes swifter towards the centre, or axis of the storm; but on the very axis there is a calm. Hence, there is first a strong wind in one direction, then a short calm, followed by a violent wind in the opposite direction. The diameter of the calm ranges from 5 to 30 miles; the commotion never extends higher than 5 miles perpendicular height, and sometimes only one mile. Sometimes the area covered by the tempest is 1,000 miles in diameter, but generally it does not exceed 200. The axis of a hurricane moves with a velocity varying from 15 to 40 miles, the average being about 20 miles an hour. The friction of the earth causes the axis to lean forward, and leads to an ascent of the lower and warmer air, which, mixing with the upper cold air, produces torrents of rain and electric explosions.

The two principal regions of hurricanes are the West Atlantic and the Indian Oceans. The Atlantic hurricanes begin generally east of the Leeward Islands, in lat. 18° N. They move north-west till they are off the coast of Florida, about 25° or 30° N., and then pass north-east along the American coast and across the Atlantic. They generally terminate south-east of Newfoundland; but sometimes they reach the continent of Europe. They describe a curve, nearly parabolic, with the focus generally a little south of the Bermudas. The circular motion of the wind, considered from the axis, is always *from right to left;* and such is the direction of all hurricanes in the northern hemisphere. A knowledge of this fact will enable the navigator to sail away from the strength of the tempest. If it blow from the east, the axis is to the south, and he should steer north; if from the west, the case is reversed. If it blow from the north, the axis is to the east, and he should sail to the west, and so on.

In the Indian Ocean, the course both of the axis and the rotating

currents is reversed. Here the hurricanes generally begin north-east of Madagascar, about long. 80° E., and lat. 10° S., and the axis moves at first south-west, towards Madagascar, and then south-east, in the direction of St. Paul's Island, describing a parabola, of which the Isle of France is near the focus. The revolving of the current is here *from left to right;* and a vessel would, of course, sail in a direction opposite to that required in the Atlantic hurricanes. The storms of the southern hemisphere generally rotate in the same direction.

Hurricanes occur when the sun is most powerful on that side of the equator—those of the Atlantic from June to October, and those of the Indian Ocean from December to April.

The *typhoons* are simply violent hurricanes, which prevail in the China Sea, and eastward to 135° E. long., their range becoming wider as we proceed eastward. They rotate like the Atlantic hurricanes.

In consequence of the centrifugal force of the air in a hurricane, its downward pressure is much diminished; and this is indicated by a rapid falling of the mercury in the barometer. The air is generally disturbed for some hours before it begins to blow with any great degree of violence; and hence, the wary mariner has time to prepare for the coming storm. The barometer has thus been repeatedly the means of saving vessels, and the lives of all on board. When the force of the storm is spent, the barometer begins to rise, and then the navigator may gradually unfurl his sails.

Although hurricanes follow a certain direction, they do not move with a uniform velocity in every part of their course; and sometimes they have been known to stop altogether for awhile, and then resume their course. Sometimes two hurricanes are simultaneous, and move in parallel directions; at other times their courses are inclined, and they meet, when a tremendous commotion ensues. A hurricane has also been known to be divided into two by a promontory.

The diminished pressure of the air occasioned by a hurricane, sometimes leads to the formation of a huge swell on the ocean. This is, of course, highest in the axis, where it is often two feet in height. This wave moves along with the tempest, and sometimes rolls against the land, whose resistance raises it to such a height that it resembles an earthquake wave, and does great damage to life and property.

Tornadoes differ from ordinary hurricanes only in being less extensive in their range, and more rapid in their motion. Common *whirlwinds* are only tornadoes on a small scale.

§ V.—Water Spouts.

Water spouts are distinguished as *terrestrial* and *marine*. The latter are found to occur in the following manner. Under a dense cloud, the sea becomes agitated with violent commotions; the waves dart rapidly towards the centre of the agitated mass of water, on arriving at which they rise, whirling round in a spiral direction towards the cloud. This conical ascending column is met by another descending column which moves towards the water and joins it. In many cases, the marine column is from 50 to 80 fathoms in diameter near its base. Both columns, however, diminish towards the middle where they often unite; so that here they do not extend more than 3 or 4 feet in diameter. The entire column presents itself in the shape of two cones joined at their apices. This column glides over the sea, sometimes without any wind being felt. Indeed, several have been seen gliding at the same moment in opposite directions. When the cloud and the marine base of the water spout move with unequal velocities, the lower cone is often seen to incline sideways, or even to bend, and finally to break in pieces. A noise is then heard, like that of a cataract falling into a deep valley. Lightning frequently issues from the centre of a water spout, or from the sides, particularly when it breaks; but no thunder is heard.

This phenomenon is explained in the following manner. Two winds of different temperatures meet; a vortex ensues. Their vapors are condensed and turned round with great velocity, so that they assume a conical form. This rotation impresses all the particles of the cloud with a centrifugal force: they are driven towards the exterior surface; a vacuum is produced within about the axis of the cone; water, or any other body lying beneath this vacuum, is carried into it by the effect of gravity, striving to re-establish an equilibrium.

§ VI.—Monsoons or Periodical Winds.

These winds prevail chiefly in the Indian Ocean. From the 10th degree of south latitude to the Tropic of Capricorn, and beyond it, the general east or south-east trade-wind prevails over all the Indian Ocean,—sometimes, in summer, extending as far as the 2d and 3d degrees of south latitude. On this side of the 10th degree, we first meet with the monsoons, or periodical half-yearly winds: from April to October, a strong south-west wind prevails, accompanied with storms and rain, while a dry and pleasant north-east wind prevails during the other 6 months. South of the 10th parallel, the trade-winds blow *regularly*.

The monsoons do not change, or, as sailors would say, do not break, suddenly. Their change, which usually takes place fifteen days or four weeks after the equinoxes, is announced by the decay of the existing monsoon, by calms and squalls in rapid succession; by storms, water spouts, tornadoes, and typhoons. The beginnings of the subsequent monsoon are liable to variations, at first, till finally it establishes an absolute dominion. The elevation to which the monsoon extends is but small, as appears in the peninsula within the Ganges, where the monsoons are arrested for several months, by the mountain chain of the Ghauts; so that the coast of Coromandel, and that of Malabar, have always their dry and rainy seasons at opposite periods of the year.

According to the preceding description, it is the south-west monsoon alone that presents any phenomenon directly contrary to the general movement of the atmosphere; for the north-east monsoon is in conformity with it. What then is the origin of this monsoon, or half-yearly wind, which in summer blows from south and south-west over all the Indian Ocean?

The monsoons always change some time after the equinoxes; they constantly blow towards that hemisphere in which the sun is found. The action of this luminary on the atmosphere is, therefore, plainly one of the causes of their origin. When its rays are reflected from the mountains of Thibet, they scorch the plains of Bengal, and the valleys of the kingdom of Siam, and rarefy the atmosphere much more than it is rarefied under the equator, where much of the heat is absorbed by the main or rendered latent in the evaporated water. This causes the southern trade-wind to come north of the equator. Here its easterly motion is more rapid than that of the earth; and therefore it blows to the north-east. This motion is further aided by the great rarefaction of the air in summer on the great central plateau of Asia. When the sun has moved towards the southern tropic, the state of matters is reversed; the southern trade-wind retreats beyond its usual limits; and the cold of the Asiatic continent enables the northern trade-wind to resume its usual course. In the same way the rarefaction of the air above the burning sands of Arabia and Beloochistan give the southern trade-wind on the eastern coast of Africa a north-easterly direction, during the summer. The southern monsoon, therefore, is simply the southern trade-wind, blowing in a north-easterly, instead of a north-westerly, direction. The south-westerly winds that blow occasionally on the Guinea coast are essentially of the same nature; and similar causes produce a northern monsoon on the coast of Brazil.

Over most part of the Indian Ocean, the northern monsoon proceeds from the north-east. On the other hand, as the seas of China, of Borneo, of New Guinea, and of Java, have the centre of Asia to

the north and north-west, the monsoon comes to them from these points. It arrives in a slow progression, in consequence of the many islands, whose elevated summits arrest and turn it aside. The north-east monsoon is mild and agreeable, because the mass of air condensed on the central platform of Asia during summer, having originally passed through the torrid zone, and afterwards remained exposed to the sun's action about the time of the solstice, has therefore lost the cold and the cloudiness which it might otherwise have acquired, from contact with the Siberian atmosphere.

§ VII.—Utility and Pleasure Derived from Winds.

The winds, it is well known, purify our atmosphere, by keeping up a perpetual agitation in it; they dissipate the miasma exhaled from marshes and from stagnant water; they excite motions in the waters which prevent them from putrefying, and assist them in absorbing the air on which their numerous tenants live; they raise and transport the clouds destined to fertilize the ground by means of rain. Millions of seeds, furnished with their little pinions, ride upon the wings of the wind, and spread afar the empire of vegetation. The ingenuity of man has made a lever of the winds, which, when applied to machinery, spares him an immense deal of toil. If the ocean is the highway of our globe, winds are the indefatigable coursers which rapidly transport our ships from port to port.

Considering winds in a picturesque point of view, how many gratifications do they procure to a lover of the great spectacle of nature! and above all, to the inhabitant of the mountains! Sometimes they spread over the valley a curtain of clouds, which shows the summits of the far distant Alps, like so many islands scattered on the surface of the ocean; at other times, they present to us all at once, a most astonishing prospect, in which the brightest sunshine forms a happy contrast with the silvery shadows. In summer and autumn evenings, it is the winds which, accumulating and marshalling their long trains of clouds, create and destroy before us, in a few moments, those aerial mountains, and fugitive landscapes, which are so variously and gorgeously tinged by the fires of the setting sun.

PART III.

CLIMATOLOGY, OR DESCRIPTION OF CLIMATES AN THEIR LAWS.

---

§ I.—Nature and Causes of Climate.

Climate comprehends the degree of heat and cold, the drou the humidity, and the salubrity, which occur in any given regio the earth. The causes of physical climate are nine in number:

1st. The action of the sun upon the atmosphere.

2d. The interior temperature of the globe.

3d. The elevation of the earth above the level of the ocean.

4th. The general inclination of the surface, and its local expos

5th. The position of its mountains, relatively to the cardinal po

6th. The neighborhood of great seas, and their relative situa

7th. The geological nature of the soil.

8th. The degree of cultivation, and of population, at whic country has arrived.

9th. The prevalent winds.

The air does not appear to acquire immediately, by the pas of the solar rays, a considerable degree of heat. This is proved the successive coldness of the higher strata of the air, which is obse upon all mountains. It seems to derive more from the radiation convection from the earth.

§ II.—Direct Influence of the Sun on Climate.

The degree of immediate solar heat received by any place, is termined by four causes. The first is the distance of the sun f the earth. If we take the mean distance of the sun, equal to 10,(the distance at the summer solstice is equal to 10,166; and at winter solstice, to 9,834; the proportion is nearly as 30 to 29. quantity of rays falling upon the same plane, being inversely as squares of the distances, their proportion will be 841 to 900, o 1 to $1\frac{1}{14}$. Thus, the quantity of solar rays which the globe rece *during* an instant in winter, is greater than that which it receive

summer. But we must remember that as it moves faster in winter, it will on that account receive the less heat while describing a certain angular space. The second cause which we have to consider, is the direction, more or less oblique, in which the rays strike the earth. This depends upon the meridian height of the sun, and therefore varies with the latitude. The more directly the rays fall, the greater is the number falling upon a given space, and the less is destroyed or lost in the atmosphere.

The third circumstance to discover, is the length of the day, or the length of that semi-diurnal arc which the sun describes. The continuity augments the effect, and the short nights allow only a small quantity of the acquired heat to radiate. The fourth, and last cause which modifies the solar heat, is the refraction which the rays experience, in passing more or less through the different strata of the atmosphere. Bouguer has calculated that, taking 10,000 rays, 8,123 of them arrive at a given point, if they come perpendicularly; 7,024, if the angle of direction is 50 degrees; 2,831, if it is 7 degrees, and only 5, if the direction is horizontal. But such calculations are of little value.

Of several methods of estimating the direct influence of the sun, we believe that to be the most reasonable, and accordant with observation, which makes it vary as the cosine of the latitude: for, the variations due to the different thicknesses of atmosphere traversed by the rays, appear to be insignificant. From this principle, it would follow, that the sun's direct influence would decrease very slowly till we go beyond the tropics. Thence to 45° it would decrease moderately; and beyond 45° it would decrease rapidly. Observation shows that such is actually the case, though the other influences mentioned above, produce wide departures from the rule in particular localities.

§ III.—Influence of the Internal Heat of the Globe.

Some persons have sought in the internal heat of the globe, for the cause of climates; and such a heat, without doubt, exists in the bosom of the globe; but if it had any perceptible influence on climate, it would act more powerfully, and with more uniformity. Its beneficial influence would be felt towards the Poles, as well as under the equator.

It has been found, that the temperature of the earth increases only about 1° Fahrenheit, for every 50 or 60 feet of descent below the surface. At the same time, the sun's influence does not extend down beyond 100 feet: for, below that point the temperature is uniform throughout the year. From these facts it necessarily follows, that the

internal heat of the earth is entirely independent of the sun; and that the climate on the surface is equally independent of the former.

§ IV.—Influence of Elevation.

With the elevation of the land, cold increases in a very rapid progression. It is superfluous to produce examples of this. It is the continued elevation of the ground, which, in Central Asia, extends the cold regions to the 35th parallel of latitude; so that in ascending from Bengal to Thibet, we imagine ourselves transported, in a few days, from the equator to the pole; and in Peru, a few hours' walk conducts the traveller from the temperature of the torrid zone, to that of the polar regions. The decrease of temperature produced by elevation, is nearly 1° Fahrenheit, on an average, for every 250 feet, from the sea level to an altitude of five miles. So that, if the heat were 80° at the sea level, it would be 20° below zero on the top of a mountain 25,000 feet high; and below the freezing point at an elevation of about 13,000 feet.

§ V.—Effects of Aspects.

Every one knows of what effect, as to temperature, is the exposure of a soil, relative to the sun. A hill inclined 45 degrees towards the south, when the sun is elevated 45 degrees, receives the solar rays perpendicularly—whilst upon a plain, the same rays strike upon the soil under an angle of 45 degrees, and a hill, inclined 45 degrees to the north, will be struck by the solar rays, in a horizontal direction, which makes them glide along its surface. If the ground is still more inclined to the north, it will receive no rays, but remain in the shade. These differences, which are easily perceptible in hilly countries, are extreme in mountainous regions. It is thus, that, in the Vallais, we see the Alps, on one side, covered with eternal ice, while vineyards and orchards adorn the opposite hills with all the charms of fertility.

There is another circumstance to be observed. The angle of incidence of the rays of the sun, is determined for any given moment of the day, by the exposure of the land; but it varies also, with the diurnal course of the sun. The hill, which in the morning received the solar rays in a direct angle, receives them more obliquely at noon,—and, perhaps the rays, in the afternoon, will merely glide over the surface of the ground. The case is precisely the reverse with hills exposed to the west. This is attended with very remarkable circumstances, which we will now explain. Every western exposure,

from south-west to north-west, ought to be warmer than the corresponding eastern exposure, all other things being equal: for, the rays of the morning, which directly strike the hills exposed to the east, have to counteract the cold which has accumulated there during the night. When the atmosphere, during the afternoon, shall have reached its greatest degree of warmth, the solar rays will no longer serve to concentrate this mass of heat upon soils lying towards the east; for they will fall only obliquely. On the contrary, those hills which incline towards the west, have already been provided with heat during the whole morning; and, as soon as the solar rays strike them in a direct manner, they collect, and concentrate all the caloric of the atmosphere, without encountering any obstacle. Everything, on the contrary, will concur in promoting their action.

According to this principle, south-south-west, and south-west situations, are the warmest of all, whilst, on the contrary, those of the north-east are the coldest.

It is scarcely necessary to observe that we speak here only of the northern hemisphere, and that we leave out of view all local and temporary circumstances.

If we consider aspects of themselves, without reference to other circumstances, we may compare the eastern one to spring, the south to summer, those of the west to autumn, and those of the north to winter.

§ VI.—Influence of Mountains.

The position of mountains is not always essentially connected with declivities of ground, since there are some plateaus which, at least as to a portion of their extent, have no general declivity; as in Mongolia and Thibet: and, on the other hand, we find countries which incline on several sides, entirely destitute of mountains; as, for example, the centre of European Russia.

Mountains act upon climates in two ways. They attract vapors suspended in the air; these vapors, by their condensation, produce fogs and clouds, which generally conceal the summit from our view.

Often, also, these assemblages of watery substances, which the winds waft in every direction, are stopped in their devious course by chains of mountains, in the elevated valleys of which they continue to accumulate.

Although mountains cannot prevent the motions of the atmosphere, they may, by arresting them, render particular winds more or less prevalent in certain tracts of country.

There can be no doubt that the Alps contribute in securing to Italy its delightful and happy climate, its perpetual spring, and

double harvests. Central and Southern Russia, on the other hand, are exposed to cold disproportionate to their latitude and exposure, which is, in a great measure, southern; and it is owing to the want of a chain of mountains in the north, which might weaken the action of the winds that blow from the White Sea, and the Uralian Mountains. Siberia is in a different and more unfavorable predicament. It slopes to the north, and consequently, lies open to winds from the Frozen Ocean; and, at the same time, its great inclination is, on the south side, crowned with the Altai Mountains, which hinder the cold winds from passing away, and also intercept the warm breezes of southern Asia.

§ VII.—Influence of Valleys.

The shelter from winds which is afforded by mountains, may sometimes become hurtful from excess. Thus, we find the heat prove insupportable, in those valleys which, in summer, concentrate and strongly reflect the rays of the sun.

When valleys are extensive and wide; when they present a considerable declivity for the flowing of waters, and afford free access to winds from the north, the temperature may then be dry, cold, and salubrious. But in valleys which are low, narrow, and hollow, and which receive dry winds only obliquely, unwholesome air stagnates, and the waters find no ready outlet, the surface becomes marshy, and dampness and fogs are apt to prevail. In such places, we sometimes meet with those feeble and stupid beings called *cretins*, who become deaf and dumb, and almost blind; and whose spiritual nature appears lost in the animal, while their necks, swollen and pendent to a frightful degree, render their very appearance disgusting. These wretched beings are confined to the narrowest part of the valleys of the Alps; and they cease to exist where the valleys widen, near the summit of the mountains, where a brisker and drier atmosphere prevails, and where the inhabitants enjoy health. The foul atmosphere and chilling damps which constantly brood over the narrower valleys of the Swiss Alps in winter, may be regarded as the true cause of goitre and cretinism. These maladies are to be found also in the low valleys at the base of the Pyrenees and Appenines, and in some of the valleys of Dauphiné and Upper Provence.

§ VIII.—Effects of the Neighborhood of the Sea.

The neighborhood of the sea moderates the excesses of temperature. In hot climates, the maritime regions are not so warm as those

of the interior; and in high latitudes, the coasts and islands are less cold than the interior of the continents. In many of the tropical isles of Polynesia, for example, the temperature is never so high as it often is at Quebec, where the mercury of the thermometer sometimes freezes in winter. In the mountains of Norway, so intense is the cold, that it has sometimes proved fatal to the Swedish armies, whose dead bodies have been found lying in ranks on the ground—while the port of Bergen does not freeze so often as the river Seine, in France. Laurels, fig-trees, myrtles, and pomegranates, which cannot subsist in the centre of France, grow naturally in abundance at Brest. The temperatures of the different seasons, also, approach nearer each other in the neighborhood of the sea. At Plymouth, in England, although the mean heat of the year is, on the whole, much less than that of Paris, the winter months are much less cold.

The cause of this is easily understood. In summer a great deal of the heat is absorbed by the water; and more becomes latent in what evaporates. In winter, again, the latent heat is set free by the condensation of the vapors; and the water radiates much of the heat it absorbed in summer. In countries far from the sea, or any great body of water, the sun's heat is freely reflected from the land in summer, and there is no extraneous supply in winter. Large bodies of fresh water have the same influence as the sea; hence the climate round the great lakes of North America is more moderate than in the same latitudes, at a distance from them or any other waters.

§ IX.—Influence of Soils.

The internal nature of the soil must have an influence on climate, in a variety of ways. All grounds are not heated equally soon. One soil quickly parts with its acquired heat, while another retains it for a long time. Clayey grounds, retaining much water, moderate the temperature, while rocky and sandy soils, allowing the water to flow off, favor extremes. Marshes and stagnant waters render the atmosphere damp and obscured by fogs. This is the reason why the winter in Holland, under 52° of latitude, is often more disagreeable than that of the Danish Islands, under the 55th parallel.

The effect of marshes in hot countries is still more unfavorable: for they ferment and evolve a great quantity of putrid effluvia, and poisonous gases. It is to these that the unhealthy coasts of tropical regions owe their pestilential climate.

§ X.—Influence of the Labors of Man.

Without the arts of cultivation, the climates of some countries would be insupportable. Let us contemplate such a country. The rivers, left to themselves, become choked, and overflow, and their waters serve only to form pestilential marshes. A labyrinth of thickets and brambles overspreads the hills; the meadows are overgrown with moss and weeds; the forests are impenetrable to the rays of the sun; no wind disperses the putrid exhalations which arise from fallen trees; the soil, excluded from the genial and purifying warmth of the air, exhales nothing but poisons, and an atmosphere of death gathers over the whole country. Observe the difference, as soon as the country is settled, rivers opened, marshes drained, and the earth opened by the plough to the influence of the sun and wind; the atmosphere, soil, and waters acquire salubrity, and a new creation springs up.

But the cultivation of a new country is sometimes attended with disastrous consequences. The moment a new soil is opened by the plough, and penetrated by the rays of the sun, it necessarily undergoes rapid decomposition, and exhales unhealthy vapors. Hence, in part, arise those epidemic maladies which ravage colonies newly established. The destruction of forests, also, is productive of evil results, when they lie rotting on the earth, and leave exposed a vast surface of country, to the exhalations of which we have been speaking, and the strong evaporative powers of a warm sun.

In the Cape de Verd Islands, the burning of the forests has dried up its springs, and rendered the atmosphere sultry. Many parts of Persia, Italy, and Greece, have thus been deprived of their delightful temperature. The cutting down of the forests, which once covered the Pyrenees, has rendered the climate unhealthy in the Valley of Azun, in the department of the eastern Pyrenees; because the absence of that barrier permits a free passage to the solano. Similar complaints are made in Castile and Arragon.

In general, the effects of clearing and cultivating a country are to render the summers hotter, and the winters colder. For the bare surface radiates the heat more freely than the forests in summer, and consequently gives out less in winter—while it allows the surface of the ground to be swept by the cold winds, and affords no shelter from the frosts. Thermometrical registers directly contradict the common opinion, that the North American winters are now warmer, and the summers colder, than formerly. Thus the mean temperature of winter at Philadelphia, from 1771 to 1775, was 34.06°, and that of summer 71.62°; while, from 1822 to 1824, the mean of winter was 32.23°, and of summer 76.16°. At Salem, Mass., the average of

winter, from 1786 to 1793, was 29.21°, and of summer 69.42°; from 1814 to 1819, the average of winter was 25.85°, and of summer 68.45°; from 1800 to 1807, the average of summer was 70.69°. Perhaps no place in the world, which is not much elevated above the sea, and is as far south as the parallel of 40°, has severer winters or hotter summers than Pekin, around which the country has been extensively cleared and cultivated for thousands of years.

§ XI.—Influence of Winds.

The particular winds which predominate over every country, variously modify the united influence of all the elements which constitute climate. But the nature, intensity, and direction of the winds depend upon general and local exposure, the neighborhood of the seas, the elevation of mountains, and other circumstances. Thus, the causes of climate form, together, a circle, of which we can point out neither the first link, nor the last.

As all the variations of winds depend upon the equilibrium of the atmosphere, the heat of one climate and the cold of another exercising a continual influence upon each other. The northern parts of a great continent will sometimes send forth their cold air towards the southern parts, and sometimes they will receive warm air in return. The heat of the torrid zone, and the polar cold, balance each other; and upon the fluctuations of their equilibrium depend several of the variations of heat and cold, which are felt in the temperate zones. All winds in the temperate zone, coming from the neighboring Pole, are cold; and all winds from the equator are hot, with some exceptions, occasioned by local circumstances. Thus the southern wind cools and refreshes the environs of the Cape of Good Hope, while the northern wind has the same effect upon Europe.

The effect of all the constant winds is to cool the equatorial regions, and warm the temperate and polar. The polar currents, in their course towards the equator, absorb much heat directly; and being much drier than the air which they come to replace, they produce a still greater degree of cold by causing a more rapid evaporation. The return currents flow towards the polar regions, heated and loaded with vapors which contain an immense amount of latent heat. As they recede from the tropical regions, they part with a great proportion of their own heat, while their vapors gradually condense, and part with their 1,000 degrees of latent heat; then they descend in the form of rain, and find their way back to the tropical regions in the polar oceanic currents. Were it not for these wise provisions of a benevolent Providence, a great part of the torrid zone would be, what the ancients generally thought it actually

was—an uninhabitable solitude, burnt up with heat. At the same time, all the polar, and a considerable portion of the temperate zones, would be equally desolate from extreme cold.

The above facts lead to a simple explanation of two phenomena, of which several elaborate and yet unsatisfactory explanations have been given, viz., the greater warmth of the western than of the eastern sides of the two continents, and the lower temperature of the climate of the United States than of the corresponding latitudes in Western Europe. The westerly trade-winds discharge most of their vapors on the western sides, because these are mostly exhausted before they reach the eastern side. The cause then is precisely that which renders the climate of the western side of Britain milder than that of the eastern: the vapors are condensed much more freely on the western side, as is evident from the fact that much more rain falls on that side of the island. Thus 32 inches is the annual fall at Liverpool, while at London it is only 23, and at Berlin, nearly in the latitude of Liverpool, it is only 19. So in the United States, the fall of rain at Green Bay, in Wisconsin, is 38 inches, while that at Portsmouth, in New Hampshire, is under 29 inches. The surprise often expressed regarding the cold winters of the northern states and Canada now receives a satisfactory explanation. We have only to go sufficiently far east in the old continent to find them equally cold; and if we go further they are colder, because the old continent has a much wider eastern range. Thus the winters are warmer at New London, in Connecticut, in lat. 41° 20' than at Pekin in lat. 39¾°,* while the summer is 10° cooler.

The more a tropical country extends from east to west, the more the trade-winds are heated by passing over the lands scorched by the sun. This is the reason why the Antilles, or Caribbee Islands, enjoy so moderate a temperature, while Senegambia is afflicted with the most overpowering heat. Congo also is warmer than Zanguebar. If the mountains of Peru have a colder climate than Brazil, it is because the elevation of ground, or any other local circumstance, may often have sufficient influence to neutralize the effect of a general cause.

Countries entirely exposed to the hot winds of the south have frequently a very warm, and sometimes an unhealthy atmosphere. Such are the coasts of Caramania or ancient Cilicia. At Satalia, and at Adana, the bad air compels the inhabitants to retire to the mountains in summer. Cilicia is a narrow plain bounded on the north by the chain of Mount Taurus; and the winds which flow from the south being reflected by the mountains, cause suffocating

* We do not mean to assert that the cause here assigned is the sole, but only that it is the main cause. The wide extent of frozen region north of America, and the neighborhood of Africa, have some influence.

heat, and there are marshes and stagnant ponds on the coast. The southern wind of the Mediterranean is known to be generally damp, hot, and unwholesome. In the Island of Lesbos, southern winds often cause epidemic complaints; and in Attica it is the same. On the coasts of the Persian Gulf, the southern winds bring on the rainy season and suffocating heat. At Bassora, the southern wind paralyzes the strength of the inhabitants, and renders them subject to fevers.

On the northern coast of Africa, the southern winds are often cold, and always dry, because they blow from Mount Atlas. At Paris, too, the southern winds are charged with the atmospheric cold of the Mountains of Auvergne. The south wind is very cold in Swabia and Bavaria, because it blows from the Alps. Everywhere, winds are modified according to the nature of the places over which they blow.

§ XII.—Classification of Climates.

The principal elements which modify climate are heat and cold, humidity and dryness. Thence there result four principal climates.

We have, first, the *hot and dry* climates. Such, in an extreme degree, is that of the deserts of Sahara, and of Arabia. The earth is scorching; the sky appears to be on fire; and even brackish water is scarce. Plants languish for want of nourishment; the men and animals, though strong and brawny, are few in number. Olive complexions and bilious temperaments prevail in the inhabitants. The most enormous reptiles, and most ferocious wild beasts, are found in Africa, and among the burning sands and jungles of Hindostan, where the intense heat seems to impart vigor and variety to their numbers.

The *hot and humid* climate prevails in Bengal, in Mesopotamia, on the coasts of Zanguebar, Senegambia, Guiana, and Panama. These countries enjoy the verdure of perpetual spring, and furnish the most gigantic productions of the vegetable kingdom; but there also, reptiles of unwieldy length wallow in the mud of marshes, steaming with pestilence. In these countries man seems to degenerate, both physically and mentally.

The *cold and dry* climate supports a hardy, though not a profuse vegetation. The waters are generally cold, pure, and hard. Animals and men are strong, active, and healthy; the moral and physical constitution are in a state of equilibrium. The light hair and white skin are characteristic of this climate, which predominates over the greatest part of Europe and a great part of Asia.

The cold and humid climate in its extreme, such as is experienced

in Labrador, envelops the atmosphere in unwholesome fogs, and reduces vegetation to a cheerless, monotonous succession of stunted woods and creeping moss. Many of the animals are covered with a thick fur, under which they remain torpid for half the year; and man himself is chiefly occupied in defending his physical life against the inclemency of the soil and climate.

A temperate climate, in the true sense of the term, denotes an atmospheric constitution, in which the hot, the dry, and the humid are equally modified, or moderated by each other. But where one of these succeeds the other, the climate is rendered more disagreeable than if one uniform temperature continued. It is thus that the inhabitants of Astrachan feel in summer the heat of Africa, and in winter the cold of Siberia.

§ XIII.—Climates of the Torrid Zone.

The torrid zone experiences only two seasons; one dry, and the other rainy. The dry season is regarded as the summer, and the wet, or rainy season as the winter of these climates; but they are in direct opposition to the celestial winter and summer, for the rain always accompanies the sun: so that when that luminary is in the northern signs, the countries to the north of the line have their rainy season. When the sun is in the zenith of a country, it causes a rapid evaporation of its waters, and continually heats and rarefies its atmosphere, whose equilibrium being thus subverted, the cold air of neighboring countries, attracted, rushes in and condenses the vapors suspended in the atmosphere, and thus occasions very heavy rains.

Those countries of the torrid zone where no vapors rise into the air, are never visited by the rainy season. It appears that local circumstances, particularly high chains of mountains, which either arrest or alter the course of the winds, exercise such influence over the physical seasons of the torrid zone, that frequently an interval of not more than several leagues separates summer from winter. In other places there are two rainy, and two dry seasons, which are distinguished by the names of great, and little. These are situated very near the equator, and correspond to the times when the sun is at the solstices, and in the equinoxes.

The heat is almost the same throughout the year, within 10 or 15 degrees of the equinoctial line; but, towards the tropics, we feel a difference between the temperature that prevails when the sun is at the zenith, and that which is felt when he is in the opposite solstice, the solar rays then falling under an angle of more than 47 degrees. We may, therefore, divide the torrid zone into three other zones, viz., *the equatorial*, which is temperate, by comparison with the second,

or *north tropical* zone, which is composed of the hottest, and least habitable regions of the earth. The greatest natural heat ever observed has been in this zone. The *south tropical* zone contains little land, but the heat is in some places intense.

The circumstances which moderate the heat of the torrid zone, are, the strong evaporation; the vast expanse of the sea; the proximity of very high mountains, covered with perpetual snow; the long nights; the trade-winds, and the periodical inundations of the large rivers. This is the reason why, in the torrid zone, we meet with all kinds of climates. The plains are sometimes burnt up, while the elevated districts are even cold. Thus the Valley of Quito is always green; and the interior of Africa contains regions which nature has gifted with the same privilege.

Nothing equals the majestic beauty of the summer in the torrid zone. The sun rises vertically; it rapidly traverses the burning clouds of the east, and fills the heavens with a light, whose effulgent splendor is often unobscured by a single shade. "The moon shines here with a more brilliant lustre; Venus blazes with purer and more vivid rays; and the milky-way glitters with increased brightness. To this magnificence of the heavens, we must add the general serenity of the air, the smoothness of the waves, the luxuriance of vegetation, the gigantic forms of plants and animals;—all nature is more grand, more animated, and less liable to change."

§ XIV.—Climates of the Temperate Zones.

The temperate zones are indemnified for the absence of tropical advantages, by the mild and varied charms of spring and autumn, by the moderate heat of summer, and by the salutary rigors of winter; although their climates are more boisterous and variable than that of any other. This succession of four seasons is not known beyond the tropics, nor towards the Poles. Even that part of the north temperate zone which lies between the tropic and the 35th degree of latitude, in many places resembles the torrid zone. Until we come towards the 40th degree, the frost in the plains is generally not intense, nor of long duration; and lasting snows are unusual. But elevated countries feel all the rigor of winter; and even in the plains, the trees are bare for several months. The temperature of a particular place, however, depends so much on other circumstances, that the mere degree of latitude is no criterion. Thus, at Bergen, in Norway, in lat. 60° 24′, the winters are rainy, rather than snowy, and there is little severe frost, while at Vienna, in lat. 48° 12′, heavy snows, and severe frosts, are not unusual.

It is *from the 40th to* the 50th degree that the succession of the

four seasons is most regular, and most perceptible; although the transitions are still so gradual as not to endanger the health of man.

The climate of the temperate zones seems best adapted to the full development of all the human faculties; and it is there alone we find the highest degree of inventive skill, united with physical vigor and strong, enduring affections. In the north temperate zone has hitherto appeared most of those characters who have contributed to the general welfare of mankind: and there is no reason to suppose, that a tide of knowledge and civilization will ever originate from any other quarter in future.

§ XV.—Climates of the Frigid Zones.

Beyond the 60th degree, and as far as the 78th, which appears to be the limit of the habitable globe, only two seasons are generally known. A long and rigorous winter, succeeded often by sudden and insupportable heats. The power of the solar beams, though feeble, from the obliquity of their direction, accumulates, during the extremely long days, and produces effects which might be expected only in the torrid zone. There have been examples of the pitch having been melted on the sides of ships. In winter, on the contrary, brandy has been frozen in heated rooms, a crust of ice has covered the bed-clothes; the earth has been found frozen to the depth of 100 feet; and the external air exhibited a temperature of 90° below zero, on Fahrenheit's thermometer. In some places, however, a southern exposure, and the neighborhood of the ocean, soften the climate to a very great degree.

The frigid zone enjoys an atmospheric calm, which is unknown in temperate regions. It has few storms, and scarcely any tempests. The splendors of the aurora borealis reflected by the snow, dispel the darkness of the polar nights; the days, for several months, though of a monotonous magnificence, astonishingly accelerate the growth of vegetation. In three days, or rather three times 24 hours, the snow is sometimes melted, and the flowers bloom.

It is frequently supposed, that the southern regions have a colder temperature than the corresponding parts of the northern hemisphere. But of this no satisfactory proof has hitherto been adduced. The winters at Quebec seem to surpass, in severity, anything ever experienced in the corresponding latitude of the southern hemisphere; and the real fact seems to be, that, owing to the greater prevalence of water in the southern regions, there is less difference between summer and winter.* It is certain, that no satisfactory reason has

* Compare the temperatures of Quebec, Gottingen, and the Falkland Islands, given in § XVIII.

ever been assigned for the antarctic regions having a colder average temperature than the arctic regions. Navigators from the north of Europe, seeing the season so cold round Cape Horn, at midsummer, and comparing it with that of the corresponding latitude in the north-western parts of Europe, would be very apt to think the southern regions colder. But if they had compared the winter of Cape Horn with that round Hudson's Bay, in the corresponding latitude, they might come to a different conclusion.

§ XVI.—General Temperature of the Globe Unchangeable.

If the earth's axis were perpendicular to the plane of the ecliptic, there would be no inequality between the days of winter and summer, and no change of seasons, as far as that depends upon celestial causes. The equator would be still more constantly heated than it is at present, and we should perceive the heat diminish on each side of it, in a very rapid progression. Each climate would have an invariable temperature, which would be that of its present spring and autumn, but very probably somewhat lower. The earth would then be scarcely habitable beyond the 45th or 50th degree of latitude. Here, then, would be that eternal spring, of which the poets wish us to deplore the want. As the obliquity of the ecliptic has been slowly diminishing for ages, it was formerly thought, that the ecliptic and the equator actually tend to coincide,—in which case the preceding supposition would be realized. But La Place has shown, that this diminution arises from the mutual attraction of all the planets, which produces only a temporary inequality, confined within determinate bounds. In short, the axis of the earth describes an ellipse; and after a long series of years, it will again point to the same spot in the heavens, and also form the same angle with the plane of the ecliptic. The range of its variations is so small, that it can produce no sensible effect on the seasons. The earth is probably radiating less and less heat into space, as it cools. But this cause is so insignificant, that it cannot have influenced the average annual temperature of the globe one fourth of a degree for many thousands of years. It has often been asserted, that the temperature of the globe is higher now than it was before the Christian era; and many facts are adduced in support of this opinion. But geology leads us to conclude, that, if there be any perceptible difference, it must rather be colder; and the facts alleged are of that isolated kind, of which about an equal number has been arrayed in support of the contrary opinion. We have already seen how little effect the labors of man have on temperature, even over the limited areas where they have any effect at all; and there is no other agency short of a miracle, to interfere with

the uniformity of the earth's temperature for an indefinitely period to come. We may, therefore, infer, that the climates of globe are now precisely what they have been since man first peared on earth, and will probably continue so until his term has pired. With respect to the heat received from the sun, we k that much of it radiates even by day; and the rest escapes by ni

§ XVII.—Climate Lines.

To render the variations of climate perceptible to the eye, l are drawn through all those places having the same temperat Of these lines there are three classes. 1st. Lines drawn thro places having the same mean annual temperature, are termed *thermal* lines, that is, lines of equal heat. 2d. Those passing thro all the points having the mean temperature of summer equal, called *isotheral*—lines of equal summer. 3d. Those joining all points which have the mean temperature of winter equal, are ca *isochimeral* or *isochimal*—lines of equal winter. If climates co uniformly from the equator, all these lines would be parallel: owing to causes already explained, they do not approach to pa lelism, except near the equator. In the north temperate zone isothermal lines are farther north on the western side of the continents, and decline rapidly towards the south as we move e ward. Thus, the isothermal line of 41° passes on the western c of North America through the Sitka Isles, in lat. 58°. Thenc curves south-east, and passes by the Bay of Fundy, in lat. 45°. then stretches north-east till it reaches the latitude of 63°, dire north of the Shetland Isles, whence it again curves south-east passes through Mandshuria, in lat. 45°. The other lines dev from each other still more widely: thus, the isochimal line of passes through New Archangel, in lat. 57°, and Pekin in lat. 39 and that of 24° passes through Eastport, in lat. 44¾°, and N Cape, in lat. 71°.

§ XVIII.—Tables of Temperatures.

I. TEMPERATURE OF THE OCEAN.

N. Lat.	In Atlantic.	In Pacific.
0°	80½°	81½°
10°	78°	81½°
20°	74°	75°
30°	71½°	71°
40°	62°	60°
50°	54°	47°
60°	44½°	39½°

II. TEMPERATURE OF THE WESTERN SIDE OF THE OLD, AND OF THE EASTERN SIDE OF THE NEW CONTINENT.

N. Lat.	Eastern Continent.	Western Continent.
0°	81° 50′	81° 50′
20°	77° 9′	77° 9′
30°	70° 7′	67° 1′
40°	63° 5′	54° 5′
50°	50° 9′	38° 3′
60°	41°	25°
70°	33°	0°

III. ALTITUDE OF THE SNOW-LINE,* IN VARIOUS REGIONS.

Lat.	Countries.	Feet.
0°	South America, (Andes)	15,795
18° N.	Mexico, (Andes)	14,772
32° S.	Chili, (Andes)	12,780
31° N.	India, (Himmalays N. side)	16,620
"	" (" S. side)	12,981
42¾° N.	Spain, (Pyrenees)	8,900
45½° N.	Switzerland, (Alps)	8,800
50° N.	Tartary, (Altai)	7,000
54° S.	Patagonia, (Andes)	3,390
60° N.	Norway, (Dofres)	5,100
71° N.	" (Mageroe)	2,160

IV. MEAN TEMPERATURE OF THE YEAR, AND OF SUMMER AND WINTER.

Place.	Lat.	Year.	Summer.	Winter.
Melville Island,	74¾°	—2°†	33.78°	—31.33°†
North Cape,	71	32	43.34	23.72
Petersburg,	60	38.84	62.06	17.06
Quebec,	46¾	41.74	68.00	14.18
Falkland Islands,	51½	46.94	53.06	39.56
Gottingen,	51½	46.94	64.7 6	30.38

* The *snow-line* is the lowest at which mountains exposed to the direct rays of the sun continue covered with snow throughout the year. This table gives the actual, and not the theoretical height of the snow-line; for the latter is affected by the amount of snow that falls, the direction of winds, the vicinity or distance of the ocean, &c. In tropical regions, the snow-line is generally below the region of perpetual frost, owing to the immense quantity of snow that falls, and the absence of long days. In temperate and arctic regions, the line is generally above that of perpetual congelation, owing to the long summer days, and the smaller quantity of snow.

† The sign — *indicates so many degrees below zero.*

Place.	Lat.	Year.	Summer.	Winter.
Edinburgh, . .	56°	47.84°	58.28°	38.66°
Dublin, ...	$53\frac{1}{3}$	49.10	59.54	39.20
Geneva, . . .	$46\frac{1}{5}$	49.28	64.94	34.70
Vienna, . . .	$48\frac{1}{5}$	50.54	69.26	32.72
Albany, . . .	$42\frac{2}{3}$	48.46	67.44	29.67
Cambridge, (Mass.)	$42\frac{1}{3}$	50.36	70.70	33.98
Paris, ...	$48\frac{5}{6}$	51.08	64.54	38.66
London, . . .	$51\frac{1}{2}$	50.36	63.14	39.56
Philadelphia, . .	40	53.42	73.94	32.18
New York, . .	$40\frac{2}{3}$	53.78	79.16	29.84
Cincinnati, . .	$39\frac{1}{10}$	53.78	72.86	32.90
Washington, . .	$38\frac{5}{6}$	57.20	76.66	38.00
Pekin, ...	$39\frac{3}{4}$	54.86	82.58	26.42
Rome, ...	$41\frac{5}{6}$	60.44	75.20	45.86
Algiers, . . .	$36\frac{4}{5}$	69.98	80.24	61.52
Cairo, ...	30	72.32	85.10	58.46
Vera Cruz, . .	$19\frac{1}{5}$	77.72	81.50	71.96
Havana, . . .	$23\frac{1}{6}$	78.08	83.30	71.24
Cumana, . . .	$10\frac{1}{2}$	81.86	82.04	80.24*

PART IV.

VOLCANOES AND EARTHQUAKES.

§ I.—Description of an Eruption.

The name *volcano* (from *Vulcanus*, the Roman god of fire) now designates those mountains which vomit forth flames, smoke, and torrents of fluid matter. The chimney through which the smoke and streams of melted matter issue generally terminates in a vast cavity, in the form of a truncated and inverted cone, termed the *crater*.

The eruption of a volcano is a most terrible and majestic phe-

* The temperature of spring at Cumana, is 83.86°.

nomenon. The signs which precede the explosion are violent movements which shake the earth afar, prolonged bellowings, subterranean thunder, which roll in the sides of the agitated mountain. Very soon the smoke, which is almost continually emitted from the mouth of the volcano, increases, thickens, and ascends, under the form of a black column. The summit of this column yielding to its own weight, sinks down, becomes rounded, and presents itself under the appearance of the head of a pine tree, having the lower part for its trunk. This hideous tree does not long remain immovable; the winds agitate its blackened mass, and disperse it in branches, which form so many trains of clouds. At other times the scene opens with more brilliancy. A stream of flame rises beyond a collection of clouds, keeps immovable for some time, and then appears like a pillar of fire which rests upon the ground, and threatens to set the sky in a blaze. A black smoke surrounds it, and from time to time intercepts the dazzling brightness. Lightning appears to flash from the midst of the burning mass. On a sudden the brilliant cascade of fire seems to fall back into the crater, and its fearful splendor is succeeded by profound darkness. The effervescence, however, goes on in the interior abysses of the mountain. Ashes, dross, and burning stones are projected in diverging lines, like the spouts of fireworks, and fall around the mouth of the volcano. Enormous fragments of rocks appear to be heaved against the sides; a torrent of water is often thrown out with impetuosity, and rolls, hissing, over the inflamed rocks. There is then raised from the bottom of the crater a liquid and burning matter similar to that of metal in fusion. This fills the whole of the crater, and reaches to the edges of the opening. An abundant quantity of dross floats on its surface, which ultimately appears and vanishes, as the liquid mass rises or falls in the crater where it seems to boil.

The substances which are thrown up from the depths of the crater by the lava, are, smoke, ashes, sands, scoriæ, volcanic bombs, and unaltered masses. The enormous columns of smoke which are seen issuing from the volcano, are chiefly composed of aqueous vapor. This vapor is generally charged with gaseous substances, and particularly with hydrogen gas, and sometimes with carbonic acid. Sulphurous acid, and hydrochloric acid, are also given out. The smoke is gray or white, sometimes brownish black or fuliginous; and the smell accompanying it then, is like that of asphaltum or mineral pitch. It often contains a quantity of volcanic ashes. The ashes, which appear to be nothing but the substance of the lava reduced to minute mechanical division, are formed of flocculent and extremely minute particles of a grayish or gray color, and forming a paste when mixed with water. They are always mixed with a greater or less

quantity of sand, which gives them the blackish color they exhibit. The torrents of gas and vapor which issue from the crater, carry these ashes with them into the atmosphere, where they form vast clouds, sometimes so thick as to cover the surrounding country with darkness. Sometimes the ashes are carried 1,200 miles, and form, where they fall in any quantity, earthy beds of great thickness, and on being heaped up and penetrated with water, they form some kind of volcanic tufa.

Volcanic sands are small particles of lava that have been ejected into the air in the form of drops, and there harden. They are fragments of scoriæ, which are mingled with numerous small crystals or fragments of augite and felspar. The quantity of these sands ejected is immense, and sometimes constitute the greater part of volcanic ejections. The smallest mingle with the ashes, and form part of the clouds already mentioned.

The gases which come from the depths of the volcano, passing through the mass of melted lava with great force and velocity, carry off some portion of that viscid matter, and bear them along into the atmosphere. In cooling, they assume the intumesced and slaggy appearance which the scoriæ of forges often present.

When the matter constituting lava is projected in a soft state, as is common, it sometimes, on cooling in the air, assumes the form of drops, tears, or elongated spheroids, which receive the name of *volcanic bombs.* These abound in the extinct volcanoes of Auvergne.

Volcanoes sometimes eject stones, many of which bear no marks of common fusion. These are considered as fragments of rocks which have been torn off and projected by some current of elastic fluids, although others think they are fragments of rocks which have been formed by igneous solution and crystallization. Monte Somma contains many specimens of such; and there they are of granular limestone, containing mica and other minerals.

The greatest velocity of ejected matter, in the cases of Mount Vesuvius and Etna, has been found to be equal to that of a cannon ball when it leaves the mouth of the gun, viz.: from four to five hundred yards per second. Cotopaxi once projected a piece of rock one hundred and nine cubic yards in magnitude, to the distance of nine miles, and it has repeatedly projected matter six thousand feet above its summit.

Lava overflows, runs down the sides of the volcano, and descends to its base. There it sometimes stops, and appears like a fiery serpent recoiling upon itself. More frequently, it dilates itself, and gushes out from behind, or beneath a species of solid crust, which is formed upon its surface, advances like a large and impetuous river, destroys whatever it meets with in its course, flows over those obstacles which it cannot overturn, passes along the ramparts of shaken

cities, invades a space of country of several leagues in extent, and transforms flourishing fields into a burning flame. Equal ravages may be sustained, though the lava does not issue exactly from the top of the cone. It is sometimes too compact and too weighty to be elevated to the summit; its violent efforts then occasion new ruptures in the side of the mountain, through which the igneous torrent rushes out.

§ II.—Geographical Distribution of Volcanoes.

A great chain of volcanic mountains stretches around the Pacific Ocean. Terra del Fuego, Chili, Peru, and the whole chain of the Andes, are full of volcanoes. We distinguish in Peru, those of Arequipa, Pichincha, and Cotopaxi, whose flames in 1738 rose higher than 2,000 feet, and whose explosion was heard at the distance of 360 miles. Chimborazo, one of the highest of mountains is an extinguished volcano. Humboldt has seen the smoke of Antisana rise 18,000 feet.

If we pass the Isthmus of Panama, we find the volcanoes of Nicaragua and Guatimala. Their number is countless, and there are some which are covered with perpetual snow.

Then come those of Mexico, viz.: Orizaba, Popocatepetl, Jorullo—which first appeared in 1759—and several others, all situated under the 19th parallel of latitude.

California contains five volcanoes that are still active. There is a number of very considerable volcanoes on the north-west of America, of which Mount St. Elias is the best known. These volcanoes form the intermediate link between those of Mexico, and those in the Aleutian Islands, and the Peninsula of Alaska.

These last, which are very numerous, both extinct and active, serve to continue the chain towards Kamschatka, where there are three of great violence. Japan has eight; and the Island of Formosa has several. The volcanic belt now becomes immensely wide, and embraces the Philippine Islands, the Ladrones, the Moluccas, Java, Sumatra, Queen Charlotte Isles, the New Hebrides, and in short, most of the Isles of Oceanica.

The eruption of the volcano on Sumbawa, one of the Moluccas, in 1815, is one of the most remarkable of modern times. The explosions were heard in Sumatra, at a distance of more than 1,000 miles; and the floating cinders beyond that island were at one time two feet thick. Of the 12,000 inhabitants of the island, only 26 survived.

The other volcanic chains are far from being of so great extent. The islands of *St. Paul and* Amsterdam, the formidable volcano in

the Island of Bourbon, and the jets of hot water in the Island of Madagascar, are the principal known limits of this chain.

The Arabian Sea flows at the base of the volcano of Gebel Tar. The neighbourhood of the Dead Sea and the whole chain of mountains which runs through Syria have been the theatre of volcanic eruptions. Around the Caspian are the volcanoes of Demavend and Elburz which connect the Asiatic chain with that of Southern Europe.

A vast volcanic zone surrounds Greece, Italy, Germany, and France. The summit of Mount Etna has burnt for 3,300 years, and is surrounded by extinguished volcanoes which appear much more ancient.

The Islands of Lipari seem to owe their origin to the volcanoes which they contain. The volcano of Stromboli, one of this group, has been incessantly active for more than 2,000 years, and is justly termed "the great light-house of the Mediterranean." Vesuvius has not always been the only burning mountain of the kingdom of Naples. Another still larger, but extinguished, has been discovered near Rocca Fina. Mount Solfaterra belongs to the same class.

The catacombs of Rome are excavations in lava-rock. Tuscany abounds in hot and sulphureous springs, and other indications of volcanoes. A great number of extinct volcanoes have been discovered near Padua, Verona, and Vicenza. Dalmatia has several. It was long suspected that a district of Hungary nourished subterraneous fires in its depths, and the eruption of a volcano has corroborated the suspicion.

Germany contains a great number of extinct volcanoes, the best known of which are those of Kamberg, in Bohemia, Transberg, near Gottingen, and those of Bonn, and Andernach, on the borders of the Rhine. The south of France is full of extinct volcanoes, among which are Mount Cantal, the Puy de Dome, and Mount D'Or, in Auvergne, which are the most conspicuous.

§ III.—Volcanoes of the Atlantic Ocean.

The Western Ocean is not, like the Pacific, encircled with a chain of volcanic mountains, but it contains in its bosom several groups of mountains which belong to that class. Although the principality of Wales, the Island of Staffa, and some parts of Ireland and Scotland exhibit only proofs of the existence of extinct volcanoes, yet the frequent occurrence of earthquakes in these regions indicates the presence of subterraneous fires; and Iceland presents to our view Hecla, Kotlonguia, and several other volcanoes, which rise up from the midst of perpetual snow.

This volcanic focus is one of the most active on the globe, for the very bottom of the ocean is, in these regions, agitated; and the waves often heave up whole fields of pumice stone, or give birth to new islands of permanent character.

Several circumstances lead us to believe that there are some volcanoes in the interior of Greenland. That frozen country sometimes experiences the shock of earthquakes; and a new island sometimes appears, evidently proceeding from submarine volcanic action.

The middle of the Atlantic Ocean conceals another volcanic focus, of which the Azores and Canary Islands have felt the effects. The Peak of Teneriffe is one of a whole system of volcanoes, parts of which are recognized in Jamaica, Guadaloupe, and Grenada.

The preceding volcanoes all belong to groups. But some volcanoes are detached, or at least belong to groups little known. Such are the extinct volcanoes of Daourie, discovered by Patrin; that which is seen in Fuego, one of the Cape de Verd Islands, and the remarkable volcano of Kilauea, in the Sandwich Islands.

§ IV.—Origin of Volcanoes.

It follows from the preceding general survey of volcanoes, that the most numerous are those found in the neighborhood of the sea, and in islands. Nevertheless, there are many which do not appear to have any communication with the sea. Another general fact is, that the craters of volcanoes burst forth in all kinds of rocks—granitic and slaty, primary and secondary rocks.

Rouelle, Desmarets, and others, attributed the origin of volcanic fire to the inflammation of bitumen, pit coal, fossil wood, and turf, or peat. But this explanation is untenable, and has been universally abandoned. An explanation more generally received was proposed by Lemery and Davy, who ascribed the volcanic phenomena to a spontaneous inflammation of metalloids from the action of water, whose oxygen was supposed to unite with them, and produce the heat and explosions. Lemery rendered this hypothesis plausible by a striking experiment. He formed a mixture of 50 lbs. of iron filings and sulphur, which, after moistening, he buried in the ground, at a certain depth; the mixture became gradually heated, and at last took fire with a great explosion. Davy performed a similar experiment. But he afterwards abandoned this hypothesis, although it is still maintained by Dr. Daubeny.

Fragments of granite, which volcanoes often project in great quantities, indicate that the lava comes from a very great depth: the long period of activity of certain volcanoes—the impossibility that the neighboring earth could furnish such copious ejections without be-

coming excavated, and sinking down*—the inconceivable force with which heavy masses of matter are projected to immense heights—and, besides the astonishing force, and the sudden explosion, the peculiar nature of volcanic fusion, which rarely produces vitrification, and which appears oftener to digest and concoct than to burn; these are circumstances which have led persons well versed in such observations to think that the reservoirs of volcanoes exist at a very great depth, and that their activity is owing to elastic gases enclosed within the bosom of the globe.

The solid matter thrown out by volcanoes consists mostly of silica and alumina, whose bases (silicon and aluminum) never unite with oxygen at common temperatures, or even at very high temperatures, except in small quantities. Another great objection to the metalloid theory is, that the gas thrown out is mostly steam, or aqueous vapor, and not hydrogen, the other element of water besides oxygen, which is expelled in comparatively very small quantities, and whose expansive force is indeed inadequate to produce the phenomena. These objections have led most geologists to reject this theory. The opinion now generally held regarding earthquakes and volcanoes, is that which we have already stated in Division 3d, Part 1st, Sect. 8. Almost every geologist now allows that earthquakes and volcanoes have a common origin. Steam is an agent capable of producing them, and we know of no other. This hypothesis is contradicted by no fact, a remark which will apply to no other.

§ V.—Earthquakes.

These convulsive movements shake the surface of the earth, either in a horizontal direction, with undulations similar to those of the sea, or vertically, when a part of the ground is raised up and the other part sinks down as into a gulf, or circularly, when ponderous masses of rocks and earth revolve as it were on a pivot. These are the three kinds of motion distinguished by the Italian writers, who are well acquainted with the phenomena. Earthquakes generally precede volcanic eruptions, and cease when the lava has got vent.

Earthquakes produce the most calamitous effects. They often change the surface of a country, in such a manner that it is impossible to recognize it. Enormous fissures or gaps emit bluish flames and deadly vapors. In the course of ages, they form new valleys.

* In the eruption of 1660, Etna erupted an amount of lava twenty times greater than the whole mountain; and in 1783, Skaptar Yokul in Iceland poured out two streams of lava, one 50 miles long and 12 broad, and the other 40 miles long and 7 broad, with an average depth of 100 feet, in some places increased to 500 or 600 feet.

n other places mountains are swallowed up or overthrown, and often detached from one another so as to glide along upon the lower ground; and as the force with which they are impelled redoubles every moment, these ambulatory rocks bound over hills and valleys. Here the vineyard descends from its height, and settles in the midst of a field of corn; there, farms, with their gardens, being lifted without separating, become attached to distant villages. In one quarter, new lakes are formed in the midst of land; in another, rocks, hitherto invisible, suddenly rear their wet summits from the bosom of the foaming sea. Springs are stopped; rivers disappear and lose themselves under ground; others, choked up by fragments of rocks, spread out into vast marshes; new springs gush out from the shattered sides of the mountain; incipient rivers strive to hollow out a channel for themselves, amidst the ruins of towns, palaces, and temples.

§ VI.—Presages and Direction of Earthquakes.

What renders earthquakes more dreadful is, that there are no signs which unequivocally designate either their approach or their termination. They happen at all seasons, and under every constitution of the atmosphere. A subterraneous noise is, indeed, their forerunner; but it is scarcely heard before the earth gives way. Animals, and particularly horses, dogs, and fowls, show, by their terror, a presentiment of its coming; and the barometer falls extremely low. Earthquakes act with astonishing rapidity. It was one single shock which, in the year 1783, overthrew Calabria, and destroyed Messina, in two minutes or less time. But these agitations are repeated for the space of months and sometimes for years, as in 1755.

The direction of earthquakes is one of the most remarkable facts in Physical Geography. Sometimes there is a central point, where the shocks are most violent, and this centre sometimes changes its place, as if the subterranean force rebounded from one point to another; sometimes we can distinguish a certain line along which this force seems to move. The sphere of such a revolution seems often to embrace a fourth part of the globe. The earthquake which caused such devastations at Lisbon, was felt in Greenland, in Norway, in Africa, and in the East Indies. The earthquake of 1601 shook all Europe and a part of Asia. In 1805, the shock was felt almost simultaneously, at Algiers, in Greece, at Constantinople, Bucharest, Kiev, and Moscow. But these distant motions are owing to a force applied at the focus of action.

§ [illegible].—[illegible] AND EFFECTS OF EARTHQUAKES.

No part of the globe appears exempt from these terrible effects. The Alps contain no traces of recent volcanic agency, and yet they are often shaken by earthquakes.* The silver mine at Konigsberg, in Norway, was first opened to view by a shock in 1603. The frigid zones also, are ever subject to earthquakes. Greenland feels frequent shocks, and in 1783, Iceland experienced violent commotions. The average number of earthquakes throughout the world, is about 20 every year; and the number of volcanic eruptions is about the same.

One of the most remarkable upheavings of earthquakes, is that of the volcanic ground of Jorullo in Mexico, which took place in 1759. For the space of half a square league, flames were observed issuing from the ground; fragments of burning rocks were thrown up to a prodigious height; and through a thick cloud of cinders, streaked with volcanic fires, the spectators thought they saw the softened crust of the earth swelling up. In the midst of the upheaved earth, the highest part of which is 1,600 feet in height, several thousand little volcanic cones arise, sending forth their smoke, and occasioning a subterraneous noise. Among these small volcanoes, six great ones rear their heads to the height of about 1,500 feet above the level of the plain.

We are informed of a volcano of considerable elevation, in the Island of Timor, called the Pic, which sank entirely down in 1638, leaving in its place nothing but a muddy marsh. And in 1772, the Papandayang, a large volcano in Java, after a short, but severe eruption, fell in, over an extent of 15 miles long, and 6 broad, burying 40 villages, and nearly 3,000 inhabitants. In such cases, the ground probably gave way from being deprived of its support, by the ejection of the lava.

The islands thrown up by earthquakes, in the midst of the sea, prove the existence of submarine volcanoes. Instances of this kind are by no means rare. Delos, Rhodes, and the Cyclades belong to this class. Isola Nuova, (New Island,) near Santorini, one of the Cyclades, was thrown up, as late as 1707. Another island rose among the Aleutian Isles, in 1796, which is 350 feet high. Another rose there in 1806, which is more than four miles in circumference. And in the same group, in 1814, there rose a peak 3,000 feet high, which disappeared after a year. A new island appeared in the Mediterranean, near Sicily, in 1831, which rose to the height of 220 feet, and disappeared, after exhibiting volcanic phenomena for some time.

* Geologists have discovered, however, that the Alps were upheaved at a comparatively recent period, though before the time of historical records.

In several cases of this sort, there is no appearance of any eruption; and the surface consists of the former bottom of the sea.

§ VIII.—Muddy Eruptions.

Nearly allied to volcanic eruptions are those of mud, a phenomenon, which, from time to time, takes place in volcanoes; but which sometimes occurs independently of them, although attributable to the same cause. Maccaluba, in Sicily, is the most terrible and celebrated of these *terrivomous* mountains, if we may so call them. In its ordinary state, mud, half fluid, is observed to boil up in the craters, or funnels, which terminate each of the small protuberances raised up on this mountain, or rather clayey hill. The mud rises in hemispheres, and falls down, after having emitted a bubble of air; but there are times when, after a great rain, all these craters disappear, the whole mass of the mountain ferments; subterranean thunders are heard, and a quantity of mud and stones spouts forth, to the height of 200 feet.

Not far from Boulogne, several quagmires, called the *salses*, situated on rising grounds, composed of saline and alkaline earths, exhibit, on a small scale, similar phenomena, emitting continually smoke and flames. The town and port of Tamar, in the Crimea, upon the border of the Black Sea, contains several hills, whence issue muddy eruptions. One of them has been seen to dart forth flames. In the Crimea also, and opposite the town of Temrak, an island was raised in the middle of the sea, in 1799, which, after having cast forth mud, flames, and smoke, disappeared under the waves. Upon a tongue of land, opposite Tamar, there was a hill, called in Tartar, Kenk-Obo, which, in 1794, experienced a terrible explosion. A column, of a pale red fire, shot up from it, to nearly 300 feet in height; and mud, mixed with bitumen, was projected to the distance of nearly a mile. The whole projected mass was computed to amount to 100,000 cubic feet. According to Pallas, it consisted of a bluish clay.

The growing, or increasing mountains which are met with at the foot of Mount Caucasus, near Baku, and near the mouth of the river Kur, belong to the same class. They are produced by springs, which throw out a salt, slaggy mud, and in this manner hills above 400 feet high are formed.

Common volcanoes throw out, though with greater violence, substances dissolved in water. Those which crown the chain of the Andes, near the city of Quito, emit only a small portion of scoriæ; but an enormous quantity of water and clay, combined with carbon and sulphur. In former ages such agencies had, probably, a great influence in the formation of some mountains.

CONCLUSION OF METEOROLOGY.

It is thus that all the elements of nature are armed for mutual destruction. What are the revolutions which we behold, in comparison to those which must have occurred in the creation of the world; and those which, perhaps, are destined one day to accomplish its final destruction? May not the stars, those suns without number, which guide the mariner in the midst of the pathless deep, be in one moment extinguished by the fiat of the omnipotent Ruler and Maker of the universe; and may not the arch of the globe upon which we stand, give way beneath our feet? Is not the equilibrium of the oceans liable to be subverted; and may not the foaming billows roll at some future day, over these continents which are now covered with the monuments of human industry and skill? May not the earth be swallowed up by the sun, on approaching very near to it, like a drop in the ocean? How frightful would it be to exist in the midst of these perfidious elements, in the bosom of this perishable universe, without the consoling faith and confidence in the infinite wisdom, power, and goodness of a supreme Creator and Father of the universe, who directs the operations of nature, and hourly sustains, by stated laws, these mighty operations, for the well-being of the human race, making all things glorify himself, and promote the improvement and happiness of his creatures.

It is only the firm and unwavering belief in an order of things superior to matter, in a moral world, that can fortify us against the terrors by which our physical existence is everywhere assailed.

DIVISION FIFTH.

BOTANY.

---

§ I.—Preliminary Remarks.

It is the province of the botanist to examine in detail the treasures of the vegetable kingdom: the business of physical geography is only to mark its general arrangements. And here, it finds abundant reason to admire that Divine Wisdom which presides over the constitution of the globe.

That certain vegetables are confined to certain districts, depending in a great measure upon soil and climate, must be familiar to most inquirers into the works of nature. With regard to climate, the two extremes are represented by the countries within the tropics, and those which surround the Poles. In one, nature exhibits herself in her most lovely, exuberant, and magnificent form, and the earth is covered with vegetables which indicate a never-ending summer; whilst in the others, a short summer calls into life a few thinly scattered, small, and stunted plants, which scarce rise above the mosses and lichens that surround them. The intermediate zones will be found to be occupied by other races, gradually, however, increasing in difference as they approach to one or other of these extremities. The same gradation may be observed on a lofty mountain situated within the tropics. At its base may be seen those plants which are peculiar to the tropics, and the beauty, grandeur, and perpetual verdure, will gradually diminish in the ascent, until a soil and climate is found on the higher summits, similar, with regard to temperature and productions, to those in the vicinity of the Poles. With regard to climate and vegetable productions, our globe has been properly compared, in its two hemispheres, to two immense mountains—such as we have just described—placed base to base, the circumference of which, at the foot, is constituted by the equator, and the two Poles represent the summits of these two mountains, crowned with perpetual glaciers. In other words, ascent above the sea level influences vegetation precisely like recession from the equator.

That every country possesses a vegetation peculiar to itself, is also well known, and this is particularly the case with countries whose natural boundaries are formed by mountains, seas, or deserts, in the same, or different degrees of latitude. Europe exhibits a widely different class of plants from that part of North America which lies immediately opposite to it.

The botany of Southern Africa has little or no resemblance to that of the same parallels in South America, or New Holland. Nay, in England alone, there are some plants which are confined to the eastern, and some to the western side of the kingdom. Nature has constituted the barrier; for, by art, they may be cultivated on either side.

Botanical geography is occupied with considering the range, or country in which plants grow, the peculiar circumstances under which they flourish, and deducing general laws from the facts thus collected.

Vegetable geography is intimately connected with horticulture; and in proportion to our knowledge of the relations of plants to the surrounding elements, will our gardens be stocked with fruits, vegetables, and flowers, our fields with grain, and our pastures with grasses. The importance of the subject is obvious from the fact that man is wholly dependent, either mediately or immediately, for his very life, upon the vegetable kingdom.

§ II.—Influence of Temperature on Plants.

Heat is a most obvious and powerful agent in affecting the existence and growth of plants; and of this we have continual experience before our eyes. In winter all vegetation is at a stand, and we can only cultivate those plants which are in a continual state of vegetation, by artificial heat. Plants are nourished through the agency of water; hence, vegetation is arrested when the temperature is below the freezing point, for the water, becoming solid, cannot circulate through the vegetable tissues. Again, in the great deserts the heat and drought are so excessive that they dry up the earth, and even deprive the air of most of its water. Hence, there is no vegetation. These effects are more remarkable on the surface of the earth than at a great depth. Hence, if there be trees whose roots penetrate deep into the soil, and reach a temperature greater in winter than that of the outer air, so that the fluids imbibed keep their interior at a degree of heat nearly the same as that indicated by a thermometer placed at their roots, such trees resist the extremes of temperature better than those whose roots are near the surface.

Powerful summer heats are capable of causing trees and shrubs to

endure the trying effects of cold in the ensuing winter. Hence, in Britain, so many fruit trees are affected by moderate frosts, while on continents the same trees arrive at the highest degree of perfection, in the corresponding latitudes. Even at Paris, the oleander will not bear in winter. For the same reason, the weeping willow becomes a large tree in England, while in Scotland, in parts where the winters are just as mild, but the summers much cooler, it requires the most favorable situations, and even then languishes.

Nothing affords a more striking proof of the influence of temperature on vegetation than a high mountain in the equatorial regions. Under the burning sun of the region at its base, bananas and plantains grow profusely; a little higher up, occur oranges, limes, and figs. Then succeed grape vines, fields of maize, and luxuriant wheat. Above these, flourish rye, barley, apples, and pears. The grasses extend a little further, and the series is closed with mosses like those of the arctic regions; these extend to the snow-line. The changes in the forest trees are equally striking, from the palms and tree-ferns of the plains, through chestnuts, oaks, beeches, and birches, till we come to the cold-loving pines. In ascending the mountains of the temperate zones, the variety is rather less, but the changes are equally striking: We may begin the ascent of the Alps, for instance, in the midst of vineyards, and pass through a succession of sweet chestnuts, oaks, and beeches, till we gain the elevation of the pines and stunted birches; and at length we tread on pastures fringed with perpetual snow.

The celebrated traveller and botanist Tournefort, found at the base of Mount Ararat the common vegetable productions of Armenia; half-way up, those of Italy and France; and towards the summit, those of Scandinavia.

The influence of temperature upon the distribution of plants, is distinguished by De Candolle under three heads, viz.:—

1st. The mean temperature of the year.

2d. The extreme temperature, whether in regard to cold or heat.

3d. The distribution of temperature in the different months of the year.

The mean temperature, which has long been considered of great importance by the physician, is in reality of the least importance, with regard to the geography of plants. It is often determined by circumstances so widely different, that the consequences and analogies to be deduced from it relative to vegetables, would be very erroneous.

By attending to the extreme points of temperature, results more limited, but far more exact, are to be obtained. Thus, every locality which, though at short intervals, affords a degree of cold or heat, intense in degree, cannot fail to produce plants which are capable of

supporting these extreme degrees. By artificial means many plants may be nourished and brought to perfection in temperatures very different from those of which they are natives; and, also, such plants can be obtained and propagated, as could not there exist in a wild state. But this acclimation of plants has its limits, and some have never been raised by human art beyond their natural ranges, although many attempts were made to that effect. Where the climate and other circumstances are favorable, exotics mingle with indigenous plants, and thrive quite as well. They sometimes grow in a climate not favorable; but they do not flourish, and their characteristic properties are apt to change. Such are the cloves and nutmegs of the Moluccas, and the cinnamon of Ceylon.

The distribution of heat at different months of the year, is found to be of the greatest importance with regard to vegetable geography. Some climates are eminently uniform. A certain mean temperature is produced by a mild winter, and a moderate degree of heat in summer. This is often the case on the sea coasts, extremes of heat and cold being moderated by the sea, which, like a vast reservoir of equal temperature, imparts to the land heat in winter, and cold in summer, and enables even tropical plants to exist in some situations of the temperate zone. Such are the western shores of Europe and America, and a great portion of the southern hemisphere. A similar mean temperature may be produced by a combination of severe winters with very hot summers; as in the great continents compared with islands, or the eastern side of those continents compared with the western, or the northern with the southern; but these two climates will produce very different vegetation.

Annual plants, which require heat to ripen their seeds, and are torpid in winter, abound most in those climates where extremes are greatest; while perennial plants are found most flourishing in temperate climates. Evergreens are most abundant where the temperature is most uniform.

The greatest number of species of plants is found within the tropics; and the proportion which the woody species bear to the herbaceous, annual, biennial, and perennial plants, decreases from the equator to the Poles; but, as an equivalent, the proportion of perennial to biennial and annual plants goes on increasing in the same direction. Near the extreme limits of vegetation, they are reckoned two to one.

We must not conclude that the same degree of elevation in corresponding degrees of latitude, is necessarily suited to the vegetation of the same plants; for the various circumstances formerly discussed may modify the degree of heat at the same elevation.

The depth of the valleys influences vegetation; the deeper they are, the more intense the cold on the summits of the neighboring

mountains, because the less heat is reflected upwards from their sides. Thus the pine does not thrive on the Bregel Mountains at a height of 5,100 feet; but it succeeds perfectly, at the same elevation, on the Rhetian Alps. The valleys surrounding the former are much deeper, and consequently they are much colder, than the latter.

When accompanied with humidity, even a high degree of heat does not destroy vegetation. Thus we see plants grow, not only on the borders of hot springs, but even beneath their waters, whose temperature we should be apt to suppose fatal to all vegetable life. Examples of this kind occur in every quarter of the globe.

§ III.—Influence of Light.

The influence of solar light on vegetation is as important as that of temperature, though it acts less powerfully on their geographical distribution. It is an agent which operates in producing some of the principal changes in vegetable life. It influences the absorption of plants; for they imbibe less humidity in darkness than in the day. It regulates the watery exhalations of the green parts of plants, which exhale little during the night or in dark places, but very freely during the day, especially in the sun.

Light is essential to the decomposition of the carbonic acid in the tissues of plants, and consequently to the deposition of carbon, the main part of their nutriment. The oxygen is returned to the air, being exhaled from the leaves and green parts. This is effected only by solar light, and it has been found that the change is produced solely by the yellow rays. The formation of the *chlorophylle*, or green matter of plants, is entirely dependent on light; and it ceases to be produced whenever the light ceases to shine on the plant. Light is also the cause of plants opening their leaves and blossoms, which frequently close after sunset and open again next morning. Some plants, however, seem to be affected by other besides solar light,—and perform their functions during the night. These form but a very small proportion of the vegetable kind. The *sleep* of plants is simply the suspension of their ordinary functions, owing to the absence of that kind of light necessary to their performance, although the variations of temperature have probably some influence. In the countries situated under the equator, an intense light, as it acts more perpendicularly, influences vegetables almost equally, during twelve hours in the day, through the whole year. In proportion as we recede from the equator, the intensity of oblique solar rays diminishes gradually till we come to those regions where solar light is completely wanting during winter, but where the cold would render it nearly useless to plants, even if they did

not shed their leaves. We may now understand why plants which lose their leaves, can better exist in northern countries, while evergreens, or those whose vegetation is continual, exist better in southern regions. They are arranged accordingly. Those plants, again, whose foliage and flowers maintain habitually and constantly the same position, flourish in northern climates where the light is almost continual in summer; while it is in the regions of the south that we find those species which are remarkable for the alternate closing and expanding, or sleeping and waking, of their flowers; a motion which has an intimate connection with the alternation of day and night. Thus we see why it is so difficult in countries remote from the equator to cultivate tropical plants. It is not the want of heat, but of sufficient solar light, which prevents the vine from ripening its fruit in Normandy, or southern England, where it is foggy; it is the long and uninterrupted action of the sun's colored rays, and not his heat, which causes the rapid development of Alpine plants in high northern regions. Plants, therefore, are arranged in their different localities according to the quantities of light which they require. Those with very watery leaves, or those which, having few organs of evaporation, need a strong stimulus to determine their action; those which have a tissue abounding in carbon, or those which contain very resinous or oily juices, or offer a large extent of green surface,—all these require much light, and are found in open or exposed places. The rest, according as they are more or less distinguished by these properties, exist under the slight shadow of bushes, hedges, walls, or forests; or as is the case with many fungi, in caves and darkness. The last are destitute of green color, being usually of a dingy white; but mosses, ferns, and some evergreens, as the ivy, flourish best, where plants that vegetate only in summer could scarcely live.

§ IV.—Influence of Water.

Water, being the vehicle by means of which much of the nourishment is conveyed into plants, is not only of the highest importance in vegetable economy, but one of the causes which affect most powerfully the geographical distribution of plants on the surface of the globe. Those vegetables in particular absorb a great quantity of water which have a spongy, cellular texture, or are furnished with large, soft leaves, or whose roots are very numerous, or of rapid growth. Plants of the opposite nature require dry situations. Great differences, however, are produced, according to the nature of the water which is absorbed; the less it is charged with nutritive principles, the more necessary it is that the vegetable shall absorb,

in a given time, enough to suffice for its support. Again, the more the water abounds with substances which alter its fluidity or transparency, and tend to obstruct the orifices of the pores, the less do such vegetables absorb in a given time. Snow is, upon the whole, beneficial to plants, by protecting them from the frosts of winter, and we may often observe sin the spring that the spots covered with snow are the first which put forth grass. The careful farmer well knows the value of snow in preserving his wheat from being winter-killed.

The nature of the substances dissolved in the water has a great influence upon the topographical distribution of plants. The matters so dissolved are chiefly carbonic acid, atmospheric air, animal and vegetable substances, and alkaline or earthy substances. Those plants whose cellular tissue is found to contain much carbon, such as trees containing hard wood, avoid more than others, the vicinity of waters which are very pure, and which contain little carbonic acid gas. Plants which exhibit much nitrogen in the composition of their secretions,—such as fungi and cruciferous plants—seek those spots, where there is animal matter in solution. Those again which present, when chemically analyzed, a considerable quantity of earthy substances, such as silica in the grasses, lime in pea-straw, &c., will require a greater proportion in the soil they occupy; and if this be naturally deficient, it must be supplied artificially before they can flourish. Those species which yield when burned a larger portion of alkaline substances than usual, can only live where these matters abound. The species which have need of carbonate of soda will only grow successfully near the sea or saline springs. But all such substances can enter the tissues of plants only by being dissolved in water: and hence the different property of the substances dissolved in the waters is one of the many causes which determine the stations of plants.

In some cases water holds in solution substances unfavorable to vegetation of any kind, such as sulphate of iron, or green vitriol. At other times it contains some substance fatal to one class of plants, which has no influence on others. Thus, the presence of some substances in water, as well as the absence of others, determines the locality of plants.

§ V.—Influence of Soil.

The tissues of all plants are composed of *lignin* or *cellulose*, a compound of carbon and water: hence, it is not surprising that plants should thrive for a time without any apparent nutriment but water, since this element always contains more or less carbonic acid, whence

the plants could obtain carbon; and they also absorb the same gas freely from the atmosphere. But the woody tissues, flowers and seeds of plants, store up within their cells various other substances, very different in composition from lignin; and the amount of the several elements required for this purpose, varies greatly in different species of plants. Thus, 1,000 lbs. of wheat contain only 2¼ lbs. of potassa, while the same weight of potatoes contains upwards of 4 lbs. 1,000 lbs. of peas-straw contain 27½ lbs. of lime, and only 10 lbs. of silica, while the same weight of wheat straw contains nearly 29 lbs. of silica, and scarcely 2½ lbs. of lime. Thus, we may see, that wheat cannot possibly thrive without an abundance of silica, nor peas without an abundance of lime.

The substances secreted by plants are almost as numerous as the genera: for, there is scarcely any genus of plants which does not contain some chemical compound peculiar to itself. Besides the compounds just mentioned, plants contain soda, magnesia, alumina, oxide of iron, sulphuric acid, phosphoric acid, chlorine, &c., although these are generally chemically combined. All these are obtained by plants exclusively from the soil; and, hence it is evident, that, if the soil should not contain what the plant requires, it cannot flourish. Plants, indeed, have a power, to a small degree, of substituting one substance for another which is similar to it: thus, if they cannot find a sufficiency of potassa, they will sometimes take an extra quantity of soda, instead: but this power is limited, and cannot be carried to any great extent without destroying the vigor of the plant, and vitiating its products. Much of the art of agriculture consists in supplying, in the form of manures, those substances required by the future crop.

It is not sufficient, however, that the soil should contain the elements required by plants: they must exist in it, in such a form as to be available. Quartz rock, for example, consists mainly of silica; yet, it is in such a form, that it cannot enter into the tissues of plants. The substance, in short, must be in such a form, that it can be dissolved by water, which is the sole medium of conveying nutriment to plants from the soil. Hence, the *form* is here as important as the substance.

Some plants, again, have a power of absorbing nutriment, and flourishing where others die. Thus, many species of moss will thrive in the soil formed from granitic rocks, by the action of atmospheric agencies, without any intermixture of decayed organic matter, while no tree will live in such circumstances. Amidst lavas, and other bare rocks, therefore, nothing but the humble plants will grow, till their decomposed remains have accumulated sufficiently to support the more complex plants.

The soil serves as a means of support to vegetables, and conse-

quently its consistence must possess a peculiar fitness for sustaining plants exhibiting very various forms. Thus, soils composed of blowing sand, can only support vegetables which are of humble stature, and flat and spreading growth, (so that the wind cannot blow them away,) or trees furnished with very deep and branching roots. The contrary holds good with regard to very compact soils. The two extremes of these soils are apt to present a scanty vegetation. Moving sands are subject to rapid currents; clay of a very compact nature, or rocks of great hardness, are equally unfriendly to vegetable growth. Where the soil is very close and tenacious, it offers too much resistance to the spread of roots, and excludes the free access of air, which is as necessary for plants as for animals.

Different soils act upon vegetation according as they absorb, retain, or part with the surrounding water, more or less easily. The celebrated Kirwan ascertained, by a comparative analysis of earths, which were considered excellent for wheat, in various countries, that they contained more silica, if the climate is subject to rain, and more alumina if the contrary was the case; and, in short, that the soil, to be good for any given vegetable, ought to have the power of absorbing more moisture in a dry climate, and less in a humid one: whence it is plain, that in different localities, the same species of vegetable may be found in different soils.

Every kind of rock has a certain degree of tenacity, and a certain disposition to decompose, or become pulverized, whence results the greater or less facility of particular soils to be formed either of sand or gravel, and composed of fragments of a determined form, &c. Those soils which decompose rapidly, furnish abundant nutriment for the support of plants, while those which are disintegrated slowly cannot support a luxuriant vegetation.

Some rocks are more susceptible than others of being heated by the direct rays of the sun, and consequently may, to a considerable degree, modify the temperature of a given place, and thus influence the choice of plants capable of thriving upon them.

§ VI.—Atmospheric Influences.

The atmosphere, in its pure state, is at all times composed of the same proportions of nitrogen and oxygen, and therefore, in this state, its influence upon all vegetables is similar. But the atmosphere, also, is of different degrees of transparency or density; other substances mix with it, in certain places, and render it more or less suitable to certain species of plants. In mines, for instance, the quantity of carbonic acid gas, or of carbureted hydrogen, may be so great as *to preclude vegetation* altogether, or only to nourish such plants as

absorb these substances especially. The air charged with saline emanations from the sea, injures some plants, and on the other hand, encourages the development of others; as may be seen in the valleys of the south of Europe, where some maritime plants may be cultivated at a great distance from the ocean, provided they lie open to the sea, and are exposed to winds that blow from it. Sulphurous fumes, and many others pernicious to animal life, have no perceptible bad effects on plants.

The most general influence exercised by the atmosphere, however, is its power of containing and parting with moisture. The atmosphere is habitually charged with moisture; sometimes in such a manner as to be invisible, and then only ascertainable by the instrument called *hygrometer*. At other times the moisture is visible, in a state of vapor, or dew. We find that vegetables, in general, flourish better in a climate where, at a given degree of temperature, the air is moderately moist, than in one where it is either too much saturated with moisture, or too dry.

The agitation of the air by winds, and other causes, exercise an influence over vegetation, by cooling at one time, and warming at another,—now bringing moisture, and now removing it; and by conveying seeds to distant parts.

Of all the atmospheric influences, the most difficult to reduce to an ascertained value, is that of density. In proportion as we are elevated in the air, the temperature, as well as the moisture, continues to diminish; and hence, it is difficult to determine how much may be due to diminished density alone. The facts that go to prove, that the diminution of the temperature upon high mountains, is one of the causes which affect the distribution of vegetables, are the following: 1. The natural situation of each plant, at a determined elevation above the level of the sea, is so much the greater, in proportion as the country is nearer the equator, and less in more temperate regions; that is, the further we recede from the equator, the greater influence has the exposure upon the temperature. 2. In temperate climates, those plants that are not influenced by temperature, are found on the summits of the highest mountains, where there is not perpetual snow. Thus, the birch, heath, and juniper, grow from the level of the sea, to the height of 10,000 feet. 3. The elevation above the level of the sea, produces effects precisely analogous to those which result from distance from the equator. In proportion as we rise in the air, the density is diminished.* 4. In proportion to the greater height upon the mountains, so will the hydrometer be

* The intensity of light is increased theoretically as we ascend; but we know, from other circumstances, that the small differences in this element can produce no sensible effect.

seen to indicate a less degree of humidity. The same general effect takes place as we recede from the equator to the Poles. 5. If plants which, according to their nature, avoid either too high or too low a degree of temperature, yet grow at different latitudes, it is at heights where the effect of elevation may compensate that of latitude: thus, the native plants of the northern plains will be found to flourish on the mountains in the south. 6. On mountains covered with perpetual snow, where the plants are constantly moistened with water in a freezing state, those to which a warm temperature is unfriendly, will live at inferior heights to those which they brave in the same latitude when they are not watered from these cold sources.

It would appear, then, from all these observations, that the situation or fixed locality of plants at certain heights, depends mainly on the fall of the temperature attributable to that elevation.

The rarefaction of the air can, therefore, directly influence vegetation, only by causing it to absorb a greater or smaller degree of oxygen, during the time of fructification. The analogy of animal respiration, however, leads us to conclude that this influence is very unimportant. Rarefaction, again, favors increased evaporation, by diminishing the pressure which checks it; and this effect must have some influence, although we know of nothing which proves that it is extensive.

§ VII.—Station and Habitation of Plants.

These are both important; the former implies their situation as regards local circumstances, and the action of physical causes on vegetables; the latter implies the geographical position. When we say, for instance, that such a plant is found in marshes, in woods, or on mountains, in England, France, or North America, we mean what is called *station*, by the first, and *habitation* by the last. Particular plants have their *stations* on the *mountains*, and their *habitations* in *America;* so that if we say such a plant grows on the mountains of N. America, this expression indicates both its station and habitation.

The seeds of plants, by varied and beautiful means, are widely dispersed by the hand of nature; while some fall on barren ground, others take root in situations harmonious to their nature, and produce, some 30, some 60, and 100 fold. There are tribes of plants which, under these circumstances, increase so prodigiously, that they destroy weaker vegetables, and appropriate to themselves a great extent of the surface of the earth. Such are termed by Humboldt, "social plants." Of this family, are the *elymus arenarius*, or "sea limegrass," and marram, or sea-reed, also called *arundo-arenarius," which* occupy a prodigious surface of sandy shores, to

the exclusion of all others, their long, creeping, entangled roots binding the sands together, and thus forming a barrier to the encroachments of the sea. Such also is the purple heath, which covers sterile moors in several parts of Northern Europe with a coarse, but pretty flower. The flowers of the gentian cover with a carpet of brilliant blue, the sides of the Alpine Hills, in Switzerland, and the south of Europe. Some of these plants are constantly striving to obtain a victory over their neighbors, till the strongest win the ground, and destroy the rest. Many low, perennial, and herbaceous plants are overpowered by a colony of taller shrubs, such as whin, furze, and broom; and these, in turn, give place to trees and shrubs of a larger growth.

There are many situations which produce only one or two kinds. The snow, in the highest arctic regions, has been discovered by enterprising travellers, to nourish and bring to perfection that highly curious vegetable called *palmella nivalis*. This minute fungus vegetates on the surface of snow as its natural abode, which gives the snow the red appearance that so surprised its early observers. The truffle, or tuber cibarium, is found entirely hid beneath the surface of the earth, for which, in France, little dogs are trained to search and bring to light, for culinary purposes.

Some fungi are detected growing upon the dead horns and hoofs of animals, and upon dead chrysalides. Both fungi and mosses grow on the earth thrown out of stables, and other animal deposits. Paper nourishes the minute *conferva dendroidea*; and window glass, if laid by in a moist place for a certain length of time, produces the *conferva fenestralis*. Wine casks, in damp cellars, produce the plant called *racodium cellare*; and Dutrochet, a great botanist, has detected living vegetables in Madeira wine, and in goulard water. All these may be numbered among the extraordinary stations.

Plants, with reference to their stations, may be divided into the following classes:—

1st. *Maritime plants.*—These are terrestrial, but grow on the seashore, or near salt lakes, as the saltworts, glassworts, &c.; hence these plants abound in the interior of Africa, and the Russian dominions, where there are salt hills.

2d. *Marine plants.*—This tribe is chiefly cryptogamic, and comprises the algæ, fuci, and ulvæ. The phænogamous, or perfect marine plants, are the sea wracks, and a few others allied to them.

3d. *Aquatic plants* growing in fresh water. Both running streams and stagnant water abound in plants. Some are quite submerged, but, with the rare exception of the little awlwort, the flowers rise to the surface for fructification.

4th. *Marsh* or *swamp plants.*

5th. *Meadow* and *pasture plants.*

6th. *Field plants.*—This tribe often includes such as, being introduced with grain, are equally placed there by the hand of man.

7th. *Rock plants*—which include the natives of very stony spots, and such as grow upon walls. These, though artificially constructed, are known to produce many plants in greater perfection than natural rock; but we must not suppose that any vegetable is confined to this habitation. The draba muralis, and holosteum umbellatum, are examples of this tribe in England; and among the mosses, the grimmia pulvinata, and fortula muralis, &c.

8th. *Sand plants.*

9th. *Plants of dry moors*—where heaths abound.

10th. *Plants attached to the vicinity of man*—such as dock, nettle, &c. These species follow human footsteps even to the huts and cabins of the highest mountains, encouraged, perhaps, by the presence of animal substances, and the nitrogen which is known to abound in them.

11th. *Forest plants*—consisting of such trees as live in society.

12th. *Plants of the hedges*—as are many climbing plants in England, such as honeysuckles, travellers' joy, &c.

13th. *Subterranean plants*—those that live in mines and caves, and which, though numerous and important, are cryptogamous. One species, a fungus, yields a pale, phosphoric light, of considerable intensity.

14th. *Alpine plants*, or mountain plants—for the limit that divides these must depend on latitude. A plant which inhabits the loftiest Alps of the south of Europe, will also live on a slight elevation in Norway and Lapland. Again, upon mountains that have no perpetual snow lying upon them, alpine plants will be found much higher, than on such as have perpetual streams of cold snow water descending from them, since these affect the atmosphere at much lower regions.

15th. *Parasitic plants*—such as the mistletoe, the various species of lauranthus, and that most wonderful of all vegetable productions, the rafflesia arnoldii. These, as their names imply, derive nourishment from a living portion of the vegetable to which they attach themselves. This is also the case with many fungi which subsist on the living foliage of plants, some on the upper, and some on the under side of the leaves.

16th. *Pseudo-parasites*—a very extensive tribe, which subsist on the decayed portions of the trunk or branches of trees, such as many mosses, lichens, &c., or such as are attached simply to trees, or other substances, without obtaining any nourishment from them, but from the surrounding element. Among this tribe, may be ranked the numerous and singular family of the orchidæ, called, from their nature *and property, air plants.*

Greatly as the preceding list might be increased, we see there is, even here, a gradation and approximation of one tribe to the other.

§ VIII.—Transmigration and Classes of Plants.

To what extent plants migrate, unaided by man, it is difficult to say; but they are supposed to be aided by the following causes:—

1st. The sea and its currents, though to a limited extent; for if the seed be of such a nature that the water penetrates its integuments, it perishes. Yet to so great a distance are seeds carried by the sea, that upon the coasts of Britain, of Iceland, and of Norway, are seeds of plants that grow in the West Indies frequently cast, and sometimes in a state of vegetation.

2d. Rivers, by the constant movement of their waters, carry many plants to a great distance; and the banks of streams usually contain a more varied vegetation than districts remote from them. Thus, too, are sassafras and other plants washed down from mountains into valleys, and flourish there.

3d. Winds, which waft the light, winged, and downy seeds to immense distances, by which means they are widely dispersed.

4th. Animals, which, in wandering about, often carry in their coats the seeds which have hooked bristles.

5th. Birds which swallow berries and other fruits, and cast the seeds on the ground in a state peculiarly adapted to germination.

Man is, however, the most active agent in dispersing, and, by cultivation, improving plants. The potato, for instance, which is a native of South America, and was first found there, is cultivated all over the world. Wheat is supposed to be indigenous in Tartary, rice in China. These and many others have been conveyed far beyond their natural habitations, and become naturalized there.

There are, however, limits to migration. The sea is an obstacle to the migration of some plants. Dry and burning deserts prove a powerful obstacle to the transportation of seeds. Thus, those districts of Africa which are separated by the Sahara, have a distinct vegetation; so that the plants of Morocco and the north of Africa have little resemblance to those of Senegal. Mountain ranges form another obstacle. Thus the plants on the Italian side of the Alps are quite different from those on the Swiss side. Those belonging to the Spanish side of the Pyrenees are distinct from the plants on the French side. The vegetation on one side of the Rocky Mountains, was found by the enterprising Drummond, to be perfectly distinct from those belonging to the other.

All plants are divided into two great classes, *flowerless*, *acotyledonous or cryptogamous*, and *flowering*, *cotyledonous or phanogamous*

plants. Of flowering plants there are two great subdivisions, *monocotyledons* or *endogens* (in-growers,) and *dicotyledons*, or *exogens* (outgrowers.) The number of species at present known exceeds 150,000, of which about 15,000 are cultivated.

Acotyledons are those plants which have no cotyledon or embryo leaf to the seed, and show no plumule in sprouting. These are all small plants, of simple structure, and destitute of hard, woody tissue. Mosses, sea-weeds, mushrooms, ferns, &c., are included in this class. Monocotyledons are those whose seeds have one cotyledon or embryo leaf; such as grasses, rushes, corn, reeds, and palms. Dicotyledons are plants which have two cotyledons to the seed, such as most of our trees and shrubs, and many herbaceous plants. This class contains many more species than the preceding. Each of these orders of plants possesses external characters and have not only a peculiar station, but their geographical distribution is different. Monocotyledons grow from within; dicotyledons grow by the addition of an annual layer from without.

The acotyledons increase in number as we recede from the equator, except the ferns, which are most numerous there. Among the monocotyledons, the palms are exclusively confined to the warm regions. The siliceous plants abound there. The dicotyledonous plants are most widely distributed, and abound in temperate and tropical climates, but most in the former. The leguminous plants, to which belong the bean and pea, &c., abound most in tropical regions, and diminish as we recede from the equator. The umbelliferous and cruciferous plants are very rare within the tropics, except on the mountains. They abound in the south of Europe, and especially about the valley or basin of the Mediterranean. Anti-scorbutic plants, so useful to the mariner after long voyages, abound everywhere, Providence having made most ample provision for every human want.

§ IX.—Botanical Regions.

To divide the globe into botanical regions is not difficult, as certain countries possess a peculiar vegetation, and numerous impediments prevent migration; while certain tribes of plants are incompatible with certain climates. M. de Candolle has described twenty of these regions,—which contain each a distinct vegetation. They are as follows: 1st. The *hyperborean* region. This region includes the northern extremity of Asia, Europe, and America, and gradually merges into the following. 2d. The *European* region, comprising all Europe, except the part bordering upon the Poles, and the southern *districts bordering* on the Mediterranean. On the east it

extends to the Altaian mountains. 3d. The *Siberian* region, comprising the great plains of Siberia and Tartary. 4th. The *Mediterranean* region, comprising all the basin of that sea, viz. Africa, north of the Sahara, and that part of Europe which is sheltered from the north by a continued range of mountains. 5th. The *oriental* region, thus called relatively to southern Europe, and containing the countries bordering upon the Black and Caspian Seas. 6th. *India* with its archipelago. 7th. *China*, *Cochin-China*, and *Japan*. 8th. *New Holland*. 9th. The *Cape of Good Hope*, or southern extremity of Africa beyond the tropics. 10th. *Abyssinia*, *Nubia*, and the *Mozambique Coast*, imperfectly known. 11th. *Equinoctial Africa*, viz. the neighborhood of the Congo, Senegal, and Niger rivers. 12th. *The Canary Islands*. 13th. *The United States of America*. 14th. *The western and temperate coasts of North America*. 15th. *The West India Islands*. 16th. *Mexico*. 17th, *Tropical South America*. 18th. *Chili*. 19th. *Southern Brazil, and Buenos Ayres*. 20th. *The countries around Magellan's Straits*.

The preceding division of De Candolle has been found to be too general, some of his districts containing various regions, each of which exhibits a peculiar flora. Professor Von Martius, of Munich, makes 51 districts, viz. 13 in Asia, 11 in Africa, 5 in Europe, 8 in South America, 4 in North America, 3 in Australia, Central America, the West Indies, the antarctic regions, New Zealand, Tasmania, Papua, and Polynesia. Even this classification is far from being sufficiently comprehensive: for Polynesia contains several botanical regions, as well as the isles in the Pacific and Southern Ocean beyond it.

The plan of this work forbids us from giving a detailed account of the productions of the many regions above enumerated, even if it were likely to prove more interesting to our readers than we think it would. For such details we refer to the larger works of De Candolle and Lindley. We shall merely give a general view of the most interesting productions of the principal botanical zones of the globe.

The empire of vegetation embraces the greater part of the globe, from beyond the polar circles to the equator, and from the summits of the Andes, where the lichen creeps over the hardest rocks, to the depths of the ocean, where fields of fuci and of algæ grow unseen. Cold and heat, light and shade, fertile lands and pathless deserts, have their respective flora, which thrives and prospers there. Let a volcano suddenly raise up from the bottom of the sea, above the boiling waves, a rock covered with scoriæ; or let the polypes elevate a flat isle of coral, and perishing, leave it: organic force is instantly ready to produce vegetation upon these rocks. Scarcely has the air

come into contact with the naked rock, when, in cold climates, there is formed upon its surface, a net-work of tufted threads, which appear to the naked eye like colored spots. Some of them are bordered by lines, bending outwards, sometimes single, sometimes double. Others are cut by furrows, which cross each other. As they grow older, their bright color darkens; the yellow which shone to a great distance, changes to brown; and the bluish gray of the leprariæ insensibly acquires a tint of dusty black. The extremities of the older coverings approach, and mingle together; and upon this dark ground are formed new lichens of a circular form, and of a dazzling whiteness. It is thus that an organic net-work is wrought in successive layers. Where the majestic oak now raises its aerial head, slender lichens once covered the bare rock.

In the torrid zones, the portacula, the gomphrena, and other low plants inhabiting the shores, supply the place, and produce the effects of lichens and mosses belonging to cold climates; and moss, grasses, herbaceous and shrubby plants, fill up the long duration between the lichen and the oak. Whence come the germs of those humble plants is not well known.

The preceding observation tends to establish certain epochs in the history of the successive propagation of the plants which cover the earth. Doubtless, where vegetation had already thrown her verdant mantle over the primary and secondary mountains, the tertiary lands might still be seen scarcely dried, covered with muddy slime, and sown with some languishing plants, rushes, mosses, and thick bushes of willows.

We ought to look upon the great chains of mountains as so many centres whence vegetation was scattered over the rest of the globe. And, indeed, the chains of the Alps, of Mount Atlas, and Mount Taurus, the central upland plain of Asia; that of Southern Africa; the Andes of South America; the Alleghany Mountains of North America, are said to be the native land of the vegetables which cover the countries lying at their bases. Some botanical districts, however, seem to have no connection with mountain chains: and, therefore, the preceding opinion of Lacepede and Ramond must be modified, to make it harmonize with facts.

We are lost in admiration, at the wonders that display themselves in the vegetable world, and at the energy of that vegetative power which, amid such great differences of situation, sustains the modified life of each individual plant, in never-ending variety of forms, and continues its species in endless perpetuity. Wherever circumstances are compatible with vegetable existence, we shall there find plants arise. It is well known that, in all places where vegetation has been established, the germs are so intermingled with the soil, that whenever the earth is *turned up*, even from considerable depths, and ex-

posed to the air, plants are soon observed to spring, as if they had been recently sown, in consequence of the germination of seeds which had remained latent and inactive during the lapse of centuries.

§ X.—Flora of the Polar Regions.

In the remote polar regions there is little or no appearance of any vegetation whatever. The palmella nivalis, or snow-plant, presents the first indication of vegetable life. Then lichens appear, of which some species have been occasionally used for food by the adventurous travellers into those inhospitable regions, although they are neither palatable nor nutritious. Still further from the Poles, appear stunted birches and willows, which rise scarcely half a foot from the ground, though they trail along the earth ten or twelve feet. When we come down further, they acquire a greater height; fir-trees appear, and cloud-berries grow in abundance. This berry flourishes best in the arctic regions, beyond lat. 70°, although it grows on the north side of the mountains, in the Scottish highlands, in lat. 57°. Immediately below the region of the cloud-berry, grow cranberries, whortleberries, cow-berries, currants, and gooseberries.

The flora of the arctic regions, though short-lived, is very brilliant, as one flower has no vigor to supplant another species, so that many kinds are found growing together. The constant glare of sunshine also contributes to impart liveliness to vegetation, and its freshness is not tarnished by slowness of growth: for a plant frequently grows, blossoms, ripens its seed, and dies, all within six weeks.

The antarctic regions present no such appearance, owing to their summers being much cooler; for it is in that season alone that polar vegetation exhibits any signs of life. For the same reason, the polar character of vegetation continues in the southern hemisphere down to a much greater distance from the Pole. Thus, the last trace of antarctic vegetation is found in the South Shetland Isles, in lat. 60° S., while the north or old Shetland Isles, in lat. 61°, produce grain, potatoes, and fruits.

Barley grows in the Faroe Isles, and near North Cape, in lat. 71°, while rye does not grow beyond the 67th, nor oats beyond the 65th parallel of N. lat. Barley requires more heat than either of the other grains; but it grows farther north, because it ripens quicker. The potato grows under the 69th parallel. The northern parts of Norway and Sweden are the only lands within the polar circle susceptible of any tillage.

§ XI.—Flora of the Temperate Zones.

In passing from the arctic regions, we still find the willow, birch, and pine; but they now attain much larger dimensions. When we come down to the parallel of 60°, the oak, elm, maple, ash, and beech, begin to appear; and wheat can be raised in favorable situations. In Siberia, no grain can be raised beyond lat. 59°. The farthest limits of tillage in North America, hitherto, has been Cumberland House, in lat. 54°; but grain could, no doubt, be raised much further north, particularly on the west coast.

The north temperate zone is the native region of the common bread grains. The mountains of Persia and Tartary are considered the original habitations of wheat, oats, and rye, while barley still grows wild in Sicily. Maize is indigenous to the temperate regions of North America.

The forest trees of the temperate zones are mostly deciduous, the proportion of evergreens being comparatively small; and the variety of the flora is not comparable to that of the torrid zone. Yet they produce in perfection the most nutritious grains, and abundance of fine fruits. The colder regions produce apples, pears, plums, cherries, currants, gooseberries, and strawberries; the warmer regions yield grapes, apricots, peaches, almonds, mulberries, figs, oranges, lemons, olives, and dates. The cork-oak is peculiar to the warmer regions of the north temperate zone, which also yields the finest cotton, and produces sugar, coffee, and rice.

The general absence of severe droughts, frequently clothes the ground throughout the year with a green mantle of verdure; and no other part of the world is so well adapted for raising flocks and herds.

The timber trees of the temperate zones hardly yield to those of tropical countries in real utility.* Here flourishes the oak, so long celebrated for strength and durability—the pine, so easily wrought into any form—the sugar-maple, which forms a substitute for the sugar-cane—the ash, in some respects superior to the oak—the box-wood, remarkable for its hard and close grain—and the cedar, whose durability is such that it has never yet been ascertained. Among the valuable herbs of temperate regions, are flax and hemp, which produce an immense variety of fabrics. They are raised between the 30th and 60th parallel. Garden vegetables are numerous and excellent, but so well known that they do not require to be enumerated.

* In size, if they do not equal some of the largest tropical trees, they are by no means diminutive. Canadian cedars are found 15 feet in diameter; and pine trees occur in California 25 feet in diameter, and 300 feet high, a height never surpassed, and seldom equalled within the tropics.

The potato, now so extensively cultivated in the Old World, is a native of the warm and temperate regions of South America.

The species of plants in the two continents generally differ, where the genus is the same. Thus, the oaks, pines, hazels, alders, and birches, of North America, are all specifically different from those of Europe. The forests of the former country present a greater variety of species; and this seems to be the cause of the peculiar richness and variety of tints observable in its autumnal forests, which uniformly strike Europeans with admiration and surprise. Many genera, however, are peculiar to each continent. Thus the numerous order of the *cactaceæ* is wholly American—and that of the *aurantiaceæ*, (including the orange and lemon,) is nearly all Asiatic:—the tea-plant, again, is wholly Asiatic—and the pine-apple is exclusively American.

§ XII.—Flora of the Torrid Zone.

The productions mentioned in the two preceding sections as flourishing in the colder regions of the globe, will not thrive in a truly tropical station. When transplanted to such a situation, they sometimes grow luxuriantly for a while, but produce no fruit; at other times, they droop and die at once. Yet the reader may remember that the elevated regions of the torrid zone will produce, in perfection, all the plants of colder regions. It produces an immense number, however, which are peculiar to itself; and it possesses this advantage over the other parts of the world, that it often can produce the peculiar productions of every region upon a single mountain.

In the variety of its productions, the torrid zone greatly excels the others, as well as in their luxuriance and magnificence; though in real beauty, it does not surpass several of the colder regions. Of all tropical regions, South America is most abundantly supplied with various species. It contains about twice as many species as Europe, nearly three times as many as Asia, and more than four times as many as Africa. The grandeur of the Brazilian flora is nowhere else equalled.

Of the bread grains, rice grows luxuriantly; and maize, though it grows in the cold regions of Canada, is raised in the plains, even under the equator.* Although the sugar-cane grows in the warmer regions of the temperate zones, it is only within the tropics that it grows luxuriantly; and it is there only that extensive sugar plantations are found. It is indigenous both in south-eastern Asia, and in

* None of the bread grains has such a wide range as maize, or produces so abundantly with little labor.

opical America. The most extensive plantations are found in the Vest Indies, and in Brazil.

Rice has been so long cultivated that its original habitation is not ertainly known; but it is supposed to be indigenous to south-eastern sia. No other grain is so extensively raised; and it forms the stale food of more than one third of the human race. It is less nutriious than wheat or maize, as it contains less gluten and earthy salts, vith an excess of starch; yet it is well adapted to the natives of varm climates, where only it flourishes. Cotton grows abundantly vithin the tropics, especially in South America and India, though enerally of inferior quality.

The cacao or chocolate nut, grows chiefly in South America. This s also the native region of arrow-root, which is now cultivated in the West Indies and Ceylon. The valuable cinchona, or Peruvian bark, s found on the sides of the Andes: there are upwards of 20 species f this tree. Pine-apples are produced in southern Mexico, Guatenala, and the West Indies. They are now raised also in southern China and India. The chermoysa, said to be the most delicious of ll fruits, grows in the same regions. Plantains, guavas, and banaas, grow in the West Indies, Central America, and South America. The same regions produce the tamarind, and the cassava or manioc oot. Of the latter there are two species; the root of the one conains a poison, which is removed by boiling or roasting. These roots nswer the same purpose as the potato; and it is reckoned that they ield five times as much nutrition as if the ground were under wheat. Tamarinds are also indigenous to India, whence the name (*tamorindy*, India-date.) The mangosteen, a fruit about the size of an range and of a delicious flavor, grows in Java and the Moluccas. The cow-tree, which yields a nutritious juice like milk, is found in Venezuela. Vanilla is produced in Mexico, and South America. The *trychnus toxicaria*, which yields the deadly woorali poison, is found Guiana. Cayenne pepper is produced chiefly in the same region. ll the finer gums are confined to tropical regions, in most of which ey abound. The same may be said of the spices. Cloves and utmeg are confined to the Moluccas, and that species of laurel which roduces the true cinnamon is found only in Ceylon.

Cocoa-nuts flourish on the sea-coasts, in most tropical countries. he tree is one of the many species of palm, of which there are early 1,000 species, mostly confined to the tropics. Dates are the uit of another species of palm, the one mentioned in the Bible: flourishes also beyond the tropics. Linnæus calls the palms, from eir noble and stately appearance, "the princes of the vegetable ngdom." Nor is their utility inferior to their beauty: they proice flour, sugar, milk, oil, flax, salt, thread, utensils, weapons, and

habitations. The Polynesians reckon about 70 uses of the cocoa-nut palm alone.

The timber trees of the torrid zone are numerous and important. The well-known mahogany grows in tropical America. The teak tree, found in the East Indies, is superior to the oak for ship-building. Ebony is found in Madagascar and Southern Asia. Rosewood is found chiefly in Brazil and Siam. The hardest and heaviest wood is generally the production of the tropical regions, which also yield most of the dye-woods, such as logwood and Brazil wood. The bamboo supplies the Hindoo with materials for building his house, and with many of his domestic utensils; and the art of the Chinese makes it supply the place of all other kinds of timber for household furniture.

Tropical trees are remarkable for their size and longevity, as well as the luxuriance of their foliage and the rich and varied hues of their flowers. The Indian fig, or banyan, attains an immense size, by throwing off-shoots from its branches, which descend, take root, and give out branches, like the original tree. These branches throw out new shoots, and so on. One of this kind in Guzerat has several hundred main stems, and would easily afford shelter to 10,000 men. The *Adansonia digitata*, or baobab, of Senegal, is sometimes found 34 feet in diameter, though it is hardly ever more than 80 feet high; and the age of one of them, ascertained from the number of concentric rings in its trunk, was found to exceed 5,000 years.* Park, the celebrated traveller, informs us that the leaves of some trees in Central Africa are so large that two or three suffice to thatch a cottage.

As the temperature is sufficiently high within the tropics to sustain vegetation throughout the year, the banks of the rivers are often clothed with perpetual verdure, thus realizing the poetical descriptions of a perpetual spring. The forests simultaneously exhibit vegetation at every degree of progress: some trees are budding, while others are in full blow, and others are shedding their leaves; and sometimes the very same tree shows, throughout the year, buds, flowers, green and ripe fruit side by side. Flowers are more frequently met with growing on trees within the tropics than in the colder regions; and they are also generally larger, more fragrant, and more variously and highly colored. Many genera of plants which are found in the temperate zones only as humble herbs, or shrubs, attain within the tropics the size of large trees. Thus we meet with ferns, grasses, and cotton plants from 20 to 50 feet high;

* The age of some of the trees of temperate regions, though less than this, is very respectable. The yew-tree at Fortingal, in Scotland, (whose circumference before it formed several trees, was 52 feet,) is upwards of 2,500 years old; and another at Braburn in England was 3000 years old.

and reeds 100 feet high are not unusual. Yet there is another aspect of the picture. The various species of cane and parasitic plants unite the forest into one impenetrable mass of vegetation, through which fresh breezes never circulate, and to which the light of the sun seldom penetrates. Myriads of noxious insects, and numerous huge reptiles and beasts of prey render the scene still more forbidding to one who has been accustomed only to the grassy fields, sunny hills, and open forests of more temperate regions.

§ XIII.—Table of the Vertical Range of Plants.*

						Height in Feet.
Limits	of	vegetation	on	the	Himmalays, north side, . .	18,000
"	"	grass	"	"	" " "	15,500
"	"	trees	"	"	" " "	14,000
"	"	"	"	"	" south side, .	11,500
"	"	grain,	"	"	" north side, .	11,500
"	"	grass,	"	"	Caucasus, ...	11,000
"	"	shrubs,	"	"	"	8,800
"	"	grain,	"	"	"	7,000
"	"	vegetation,	"	"	Andes, lat. 0°, ...	22,000
"	"	grass,	"	"	" "	17,500
"	"	trees,	"	"	" "	16,500
"	"	wheat,	"	"	" "	13,000
"	"	plantain,	"	"	" lat. 5°, ...	3,500
"	"	sugar-cane,	"	"	" "	5,000
"	"	maize,	"	"	" "	8,000
"	"	potato,	"	"	" "	13,000
"	"	trees,	"	"	Mexican Andes, lat. 20°, .	12,500
"	"	sugar-cane,	"	"	" " " "	5,700
"	"	trees,	"	"	Pyrenees, ...	10,900
"	"	"	"	"	Alps, south side, ...	6,700
"	"	"	"	"	" north side, ...	5,900
"	"	shrubs,	"	"	" south side, ...	7,500
"	"	vines,	"	"	" " "	2,000
"	"	trees,	"	"	Dofres, lat. 66½°, . . .	2,000

* We give only round numbers, as so much depends on local peculiarities that greater exactness would lead to inferences only partially true.

DIVISION SIXTH.

ZOOLOGY, OR DESCRIPTION OF THE PECULIARITIES AND DISTRIBUTION OF ANIMALS.

---

§ I.—Preliminary Remarks.

The Almighty Power that created and set in motion the springs of animal life, has so wisely and beautifully ordered the whole system in its grandest developments, and its minutest parts, that the laws which govern the different species of animated creation in their nature and habits, are as distinct, and as perfect in their operation as uniform in their result. From the half vegetable, half breathing zoophite—the last connecting link between man and the dust from which he sprung—to the half reasoning elephant, the noblest of the animal creation, and the nearest in intelligence to the human race, the attentive inquirer can trace a wonderful and harmonious arrangement of faculties and of circumstances, adapted to the support and comfort of each separate species, until he arrives at the image of the Deity, with eye and front so beautifully constructed, as not only to survey at a glance the grandest and the minutest charms of nature, but also to look up to Heaven and acknowledge the power, wisdom, and goodness of that glorious Being who created all things, and who formed man with a view to prepare his spirit for a still loftier and holier state of existence, where knowledge will be without limits, and without end.

§ II.—General View of the Animal Kingdom.

The most superficial survey of nature is sufficient to show, that there prevail certain general resemblances, among great multitudes of species, which lead us to class them into more or less comprehensive groups. Thus, in the animal kingdom, quadrupeds, birds, fishes, reptiles, shell-fish, and insects, compose natural assemblages, or

classes; and each of these is readily divisible into subordinate groups, or families.

Upon a close examination of the structure and economy of plants and animals, we perceive that the formation of all the individual species, conprehended in the same class, has been conducted by an all-wise and all-powerful hand, in conformity, so to speak, with a certain type, or mould. Of this general type, all the existing forms appear as so many separate copies, differing in particulars, but agreeing in general characters. The same observation applies to the families, the genera, and other subordinate groups of living beings.

The more extensive our acquaintance is with the anatomy and physiology of plants and animals, the more striking do these analogies appear; so that, amid endless diversity in the details of structures, and of processes, the same general purpose is usually accomplished by similar organs, and in similar modes. So firmly is this principle established, that naturalists often venture, with confidence, to predict or describe many circumstances relating to an unknown animal, of which only a few fragments are presented to them, from their general knowledge of the characters and economy of the tribe, on the type of which it has been modelled. Thus, the discovery of a mutilated portion of the skeleton of a fossil animal conveys to the physiologist, who is conversant with the details of comparative anatomy, a knowledge of the general structure and habits of that animal, though all other traces of its existence may have been swept away, amid the primeval revolutions of the globe.* So complete is the distinction of species, that the microscopic structure of a bone is sufficient, in many cases, to identify the species to which an extinct or unknown animal belonged.

Not only does this tendency to conform to types obtain in all organic formations, but further inquiry leads us to the conclusion, that deviations from these standard forms, far from being accidental or arbitrary, are referable to definite laws. The regulating principle of the variations is subordinate to higher views, and has reference to the respective objects and destination of each particular species, in the general system of created beings. Providence, as far as we can discern, appears, in conformity with these intentions, first to have laid down certain great plans of functions for the operation of nature, and to have adapted the structure of the organs to these functions, the minor objects and more subordinate functions being accommodated to this general design. Hence arises the necessary and reciprocal dependence of each organ, and of each function, on every other; and hence are deduced, what are called the laws of the co-

* Professor Owen of London has repeatedly given an account of the leading characteristics of an animal after carefully examining a single bone; and his descriptions were verified by subsequent discoveries.

existence of organic forms. By attention to these laws, may often be explained how each variation that is observed in any one organ, common to a natural group of animals, entails certain necessary and corresponding variations in other parts, and extends its influence, in modifying in a greater or less degree, the whole fabric. It is in comparative anatomy, as in mechanics, where any alteration made in the position of one part of a system of bodies, occasions a change in the centres of gravity, of gyration, and of oscillation, and evolves new mechanical forces, and conditions of equilibrium, which render new adjustments in other parts necessary, in order to restore the equipoise, and preserve the harmony of their movements.

All beings are connected by mutual relations. Even among the leading types, which represent the great divisions of the animal kingdom, we may trace several points of resemblance, which show them to be parts of one general plan, and to have emanated from the same Great Creator of all. In the progress of discovery, we are always meeting with species which occupy intermediate places between adjacent types, and appear as links of connection in the great chain of being. It often happens, that throughout an extensive series of organic forms, the steps of gradation by which one type passes into another are so numerous and so regular, as to preclude the possibility of drawing a decided line of demarkation, between those that properly appertain to each. All these apparent anomalies and gradations of structure, tend still further to demonstrate the generality of the plans of nature and Providence, and the comprehensiveness of the design which embraces the whole series of animated beings.

These views are strongly corroborated, by the discoveries that are continually made of species now no longer in existence, but which, in former ages of the world, helped to fill up many of the chasms which now interrupt the continuity of that series. This knowledge has been revealed to us by the examination of their fossil remains, those monuments of former epochs, which have thrown such important light on the most interesting questions in geology as well as in physiology.

In every department of nature it cannot fail to strike us, that boundless variety is a characteristic and predominant feature of her productions. It is only when the object to be attained is dependent upon certain definite conditions, excluding the possibility of modifications, that these conditions are strictly and uniformly adhered to. But wherever that absolute necessity does not exist, and there is afforded scope for deviation, there we are certain to find introduced all those modifications which the occasion admits of. Not only is this tendency to variety exemplified in the general appearance and form of the body, but it also prevails in each individual organ, how-

ever minute and insignificant that organ may seem to be. While the elements of structure are the same, there is presented to us in succession every possible combination of organs, as if it had been intended to exhaust all the admissible permutations in the order of their union. Some wise purpose, though dimly perceptible to our imperfect understandings, is doubtless answered by this great law of organic formation, the law of variety. That it is not blindly nor indiscriminately followed is apparent from its being circumscribed within certain limits and controlled by another law, which is that of conformity to a definite type. We cannot take even a cursory view of the host of living beings profusely spread over every portion of the globe, without a feeling of profound astonishment at the inconceivable variety of forms and constructions to which animation has been imparted by creative omnipotence! What can be more calculated to excite our wonder than the diversity exhibited amid the endless modifications of shape by the insect tribe which still preserve their conformity to one general plan of construction? The number of distinct species of insects already known and described amount to 120,000; and every day adds to the catalogue.

Of the comparatively large animals that live on land, how splendid is the field of observation lying open to the naturalist! What variety is conspicuous in the tribes of quadrupeds and reptiles! and what endless diversity exists in their habits, pursuits, and characters. How extensive is the study of birds alone! and how ingeniously, if we may so say, has nature interwoven in their construction all possible variations, compatible with an adherence to the same general model of design, and the same ultimate reference to the capacity for motion through the air!! What profusion of being is displayed in the wide expanse of the ocean, through which are scattered such various and such unknown multitudes of animals! Of fishes alone, the varieties as to conformation and endowments are endless. Still more curious and anomalous, both in their external form and their internal structure and economy, are the numerous orders of living beings that occupy the lower divisions of the animal scale; some swimming in countless myriads near the surface; some dwelling in the inaccessible depths of the ocean; some attached to shells or other solid structures, the productions of their own bodies, and which, in process of time, form, by their accumulation, enormous submarine mountains, rising often from very great depths to the surface! What sublime views of the magnificence of creation have been disclosed by the microscope in the world of infinite minuteness, peopled by countless multitudes of atomic beings, which animate almost every fluid in nature! Of these a vast variety of species has been discovered, each animalcule being provided with appropriate organs, endowed with spontaneous powers of motion, and

giving unequivocal signs of individual vitality! The recent observations of Professor Ehrenberg have brought to light the existence of monads, which are not larger than the 24,000th part of an inch in length, and which are so thickly crowded in the fluid as to leave intervals not greater than their own diameter. Hence he has made the computation that each cubic line, which is nearly the bulk of a single drop, contains 500,000,000 of these monads; which almost equals that of all the human beings on the surface of the earth. Thus, if we review every region of the globe, from the scorching sands of the equator to the icy realms of the Poles, or from the lofty summits of the mountains to the dark abysses of ocean; if we penetrate into the shades of the forest, or into the caverns and secret recesses of the earth,—nay, if we take up the minutest portion of stagnant water, we will meet with life in some new and unexpected form, yet ever adapted to the circumstances of its situation. Wherever life can be sustained, life is produced. Every element, every clime, is filled with sensitive beings, and scenes of wonder and enchantment are displayed in endless variety, inscrutable complexity, and perpetual mutation.

Our attention, when called to the study of nature, is solicited to a vast multiplicity of objects, curious and intricate in their mechanism, exhibiting peculiar movements, actuated by new and unknown powers, and gifted with high and refined endowments. In place of the simple combinations of elements, and the simple properties of mineral bodies, all organic structures, even the most minute, present exceedingly complicated arrangements, and a prolonged succession of phenomena, so varied, and so anomalous, as to be utterly irreducible to the known laws which govern inanimate matter. The more we extend our knowledge of the operations of creative power, as manifested in the structure and economy of organized beings, the better we are qualified to appreciate the intentions with which the several arrangements and constructions have been devised, the art with which they have been accomplished, and the grand comprehensive plan of which they form a part.

Beginning with zoophytes, the lowest of the animal creation, as a natural and progressive step from the vegetable kingdom, to which the preceding division has been devoted, we will take a hasty survey of the ascending links in the chain of animals, until we reach the highest grade.

§ III.—Porifera, or Sponges.

Among zoophytes, (*zoo-phyta*, animal-plants,) the lowest station in the scale of organization is occupied by the tribes of *porifera*, or

sponges, which name was given by Dr. Grant, to the animals which form the various species of sponge, and which are met with in multitudes, on every rocky shore of the ocean, from Greenland to Australia. Sponges grow to a large size near the tropics, and are more diminutive and finer as we approach the Poles. They are met with equally, in places covered by the sea perpetually, and in those which are left dry. They adhere to the surface of rocks, and other marine animals, to which they are so firmly attached, that they cannot be removed without lacerating and injuring their bodies. So they are like some plants, of a parasite nature.

They flourish best in cavities of rocks, but come to maturity even in spots exposed to the unbroken fury of the surge. They line with a variegated and downy fleece, the walls of submarine caverns, or hang, in living stalactites, from the roofs. In their general appearance, they resemble vegetables; but in their organization, they differ entirely from every vegetable production, being composed of soft flesh, intermixed with a tissue of fibres, some of which are solid, others tubular. The substance of which this solid portion or basis is formed, is partly composed of horn, partly of siliceous or calcareous matter. It has been termed the axis of the zoophyte; and as it supports the softer substance of the animal, it performs the office of skeleton, giving form and protection to the entire fabric.

The material of which the fleshy substance is composed, is of so tender and gelatinous a nature, that the slightest pressure is sufficient to tear it asunder, and allow the fluid parts to escape, and the whole soon melts away into a thin, oily liquid. When examined with the microscope, the soft flesh is seen to contain a great number of minute grains disseminated through a transparent jelly. There is a constant current of liquid matter pouring out from the circular cavities under the surface of the sea, which throws off a quantity of dark matter, and the circular apertures in the sponge are intended to discharge this current, which only ceases when the animal dies.

Some species of sponge have a kind of skeleton composed of a tissue of needle-shaped crystals, of carbonate of lime, or of silica. The animal moves forward by means of vibrations in the water.

The young sponges, as soon as they leave the parent, attach themselves to the sides or bottoms of vessels, and some are seen spread out like a thin, circular membrane on the surface of the water. They advance by means of cilia, or short filaments, which are in constant and rapid vibration, and are spread over two thirds of the surface of the body.

The sponge has a consciousness of feeling, for on striking against any obstacle, they stop their cilia or oars, which are minute and transparent, wheel round the spot for a few seconds, and then renewing the vibrations, proceed in their course. And this distinguishes

them from every kind of vegetable. Thus has a power of spontaneous motion been given to the lowest order of the animal creation. Many species which abound in the Red Sea and Indian Ocean, have been transported by the equinoctial current from the eastern waters to corresponding latitudes in the New World.

§ IV.—Polypifera.

The next grade of zoophytes are the polypes, (*poly-pous*, many-footed.) The transition from the structure of the sponge to that of the polypus, may be thus described:—suppose the absorbing cells, or orifices of the sponge, to be enlarged, and their number reduced, and let these orifices be drawn out into tubes, and provided with vibratory cilia; in addition to which, let there be placed around their margin a circular row of larger filaments, extremely flexible, and capable of twining round any object that comes within their reach, and of conveying it to the central orifice, which performs the office of mouth. Each tube thus furnished with a circle of radiating filaments, called *tentacula*, or tenticles, is called a polype. The entire animal mass composed of an aggregation of these polypes, is called a *polypus*. It is also called *lobularia*.

Polypi form a very extensive order of zoophytes, abounding in every part of the ocean, but growing in the greatest luxuriance in the tropical regions, and near the equator. Their flesh exhibits the same granular appearance as that of the sponge, but it is generally firmer, and often intermingled with calcareous matter. The tentacula, which may be compared to arms, vary in length and number, in different species of polypi, and instead of a single row, each of the mouths has two or more series of tentacula placed around it. They are formed of a prolongation of the soft substance of the polypi, and are sometimes tubular, and their cavities are then continuous with that of the general internal cavity into which the mouths open. Besides being flexible in every direction, the tentacula or arms, are also capable of being lengthened or shortened at the pleasure of the animal. Their elongation is effected by the propulsion of a fluid into their interior, derived from the general cavity of the body, and their retraction by the return of the same fluid. The whole arrangement of the tentacula on the margin of the projecting mouths, bears a resemblance to a flower, especially to the China aster.

In the construction of zoophytes the Creator seems still to keep in view the models of vegetable forms, the characters of which, when He is effecting the transition from one kingdom to another, He continues to impress on His productions. All zoophytes, both in out-

ward form and internal construction of organs, preserve the symmetrical arrangement round a common centre, generally exhibited in flowers; and the affinities which these lower departments of the animal kingdom retain with plants, are more marked, and more predominant, as the organs of zoophytes are more developed. Hence, the star-like forms, and the name of radiate.

Polypi are generally attached to a horny base, or a calcareous one in the form of a shell, which, in shape, admits of infinite variety. Sometimes this shell constitutes the external surface of the animal, and encloses the flesh in a general sheath, with openings to let out the ends of the tentacula; at others, these tubes are joined like branches of a tree; and sometimes like pipes in an organ. The material composing the axis to which the polypes are attached, is various,—sometimes horny, flexible, and elastic, corresponding to animal membrane; at other times they are composed of carbonate of lime, and phosphate of lime. In all cases the particles of calcareous matter are united together by some portion of animal substance, which may be obtained by dissolving out the former by an acid. Sometimes the stem consists of horny pieces, formed into jointed structure, which is the case with isis hippuris, or jointed coral. The structures are generally attached to submarine rocks, by an expansion of the base into a kind of foot, or root, which has strong power of adhesion. In this respect, these animals preserve an analogy with plants.

It has been discovered, that these fixed zoophytes are multiplied like the sponge, by the detachment of gemmules, or imperfectly formed portions of their soft substance, which undergo a metamorphosis, to bring them to a perfect state; and the moment they are detached, they exhibit a singular spontaneous motion, swimming in various directions, by the rapid vibrations of their cilia, till they find a place favorable for their growth. On becoming fixed, they spread out to form a base, and then shoot upwards, depositing a calcareous, or horny axis, in successive layers, till it has acquired the requisite thickness, and then gradually assume the forms of the species to which they belong. The materials thus deposited are permanent structures, not capable of removal, and devoid of vital properties; for these properties belong exclusively to the animated flesh with which they are associated. The polypes attached to these structures are not developed till after the formation of the root and stem; their growth being thus analogous to that of the leaves and flowers of plants. The gemmules float or swim for a few days after they leave the parent cells, and then in some still water fix themselves; and in a short time the cilia disappear, and bundles of fibres appear, which connect the head of the polype, and the moment it protrudes from its cell, it is an *adult polype,* and vibrates the cilia of its tentacles, or arms,

with as much velocity as at any future period. The tentacula of polypi are exquisitely sensitive, and are often seen like long, slender feelers of a spider, either singly or together, bending their extremities towards the mouth, when any minute floating body comes in contact with them. Each polype has 22 tentacles, or arms, and about 50 cilia on each side of a tentacle,—making 2,200 cilia, or arms, on each polype. The cilia seem to depend in their motion, (which is too rapid for the finest microscope to detect,) upon some unknown physical cause connected with the life of the animal.

A question arises with regard to the constitution of these zoophytes, viz., whether the whole mass, which appears to grow from one root, and consists of multitudes of branches, proceeding from a common stem, is to be considered as one individual animal, or an aggregation of smaller individual animals, each individual being characterized by having a single mouth, with its accompanying tentacula; and yet the whole animated by a common principle of life and growth? Naturalists generally decide on the latter, regarding each portion provided with distinct tentacula, as a separate animal.

Immense numbers of these curious animals are found in every part of the ocean. The pennatula, or sea-pen, which resembles a quill in form and structure, is of this description. It swims through the water by its own spontaneous movements, according to Cuvier; but Dr. Grant thinks they only obey the impulse of the currents. It is only when the contractile flesh of the polypus is released from the restraint which the solid axis imposes on its movements, that the animal becomes capable of any distinct power of locomotion. Such is the condition of the genus hydra, of which the hydra viridis, or fresh water polype, is the type.

This singular animal presents us with apparently the simplest structure that exists in the animal kingdom. The hydra appears to consist of nothing but a fleshy tube, open at both ends, one of which being more dilated, may be regarded as the head, and has for a mouth the aperture of the tube, furnished round the margin with a single row of tentacles. These tentacula are surrounded with very minute cilia, which are incessantly in motion, independent of the animal's will. This motion causes a current, which brings minute particles of matter within the mouth. The tentacles can be elongated to a great length, or retracted and bent in every direction so as to grasp any small object that it finds. The body tapers to a small point, where it flattens and becomes the pedicle; and it is by this that the animal attaches itself to the bottoms or sides of vessels in which it is kept. It walks by putting down the foot first, and then the head, holding on to one or the other. They are generally found attached to aquatic plants, and feed on insects. When alarmed, it

shrinks into a small globule, almost imperceptible. Its substance consists of gelatinous matter, filled with grains.

Before we leave the subject of polypi, we shall speak of the coral, which is so familiar as an ornament, both red and white, to the common observer. It is a species of polypus, which exhibits the closest resemblance to the branched forms of vegetable stems. The flesh of this contains granules of calcareous matter, which, in the dried specimens, adhere to the surface of the stems. The animal is imbedded in the centre in a tube, and its tentacles are annexed to the branches of the tree or plant.

There are three great seas of coral on the globe. First, that part of the Pacific Ocean where flat islands appear, such as the Friendly Isles, New Caledonia, Solomon Isles, &c. It is there, between the different parts of the oceanic division of the world, that the mariner is in danger of striking against rocks of coral, shooting up from a considerable depth. The second region extends from the coast of Malabar, to that of Madagascar, and Zanguebar. The Mediterranean forms the third region; and the valuable coral which it furnishes, and which is in great demand, from Africa to Japan, essentially differs from the coarse substances of which the islands in the southern sea are composed. The coral polypes commence building 20 or 30 feet below water, and build until they are above low-water mark, where they generally perish. The sea now washes upon the coral structure, fragments of rock, drift-wood, &c., until a soil is formed, on which vegetation gradually appears. Some kinds of coral polypes are supposed to begin building 100 feet below the surface. They always commence on the tops of submarine mountains, and sometimes round the submarine crater of a volcano. In the latter case, the structure rises from the water in the form of a circle, enclosing a lake, and forming what is called an *atoll*, or lagoon island. Coral structures are sometimes elevated by volcanic action, and sometimes covered over with lava. The whole class is confined to the seas of warm countries; and the species found in any locality depends partly on the temperature, and partly on the state of the water.

§ V.—INFUSORIA.

The infusory animalcules were so named by Muller, a Danish naturalist, from the circumstance of their swarming in all infusions of vegetable or animal matter that is kept too long to be wholesome.* They are far too minute to be seen except through a microscope.

* We are aware that the infusoria belong to several classes, some of them being in reality crustaceans; but in a work like the present, it is unnecessary to alter the usual classification of animals so very minute.

We know so little of them, that it is difficult to assign them their true place in the scale of animals; but they are considered by naturalists, to exhibit the simplest of all possible conditions to which animal life can be reduced. The monads are the most diminutive of this tribe, and their presence can be detected only by the application of the highest magnifying powers. It has been established as a fact by Ehrenberg, that they possess internal cavities for the reception and digestion of food, and that their organization is equally complex with that of the larger species of infusoria, such as the rotifera, in which he has discovered traces of a muscular, a nervous, and a vascular system. Some are covered with a siliceous case; and the remains of these sometimes constitute whole mountains, although they were so small that it would take 40,000,000,000 to form one cubic inch. They are of various shapes and forms. The proteus looks like a mass of soft jelly, highly irritable and contractile, at one time shrunk into a ball, at others, stretched out like a ribbon, and sometimes taking the form of a star. The rotifera, or wheel animalcules, are so named from their being provided with an apparatus for creating a perpetual eddy or circular current in the surrounding fluid. They are two in number on the head, but do not surround the mouth as is the case with other polypes. They consist of circular disks, with rows of cilia resembling a crown wheel, which perpetually revolves.

§ VI.—Medusæ and Actinia.

Floating masses of living gelatinous matter are met with in every part of the ocean, often in vast numbers, and of various forms, and having little appearance of belonging to the animal kingdom. The *medusa* is the prevailing type of this family. They appear to be raised but a single step above the polypi, and in point of activity rank among the lowest of the zoophytes that are not stationary. They are wholly passive beings, floating on the surface of the sea, remaining at a small depth below, and carried to and fro by every current, being the prey of innumerable tribes of animals that people the ocean. The usual form of the medusa is that of a hemisphere, with a marginal membrane, like the fold of a mantle, extending loosely downwards from the circumference, and with a central pedicle, like the stalk of a mushroom, and terminating in several fringed laminæ, or tentacles. It might almost be called sea-mushroom. The whole substance of the body is semi-transparent and gelatinous, possessing great elasticity, and some contractile power. The animal flaps the fringed pedestal, and opens and shuts the margin of its hemisphere, like a parasol. They descend in the water by

contracting themselves. The larger kind abound in the seas around England; and the smaller ones, in every ocean in the world. One cubic foot of water was found, by Mr. Scoresby, to contain 100,000 of them. Some have been found with traces of a nervous system, and of simple organs of vision.

The *Physalia*, or Portuguese man-of-war, is furnished with a large air bladder, of an oval shape, on the upper part of the body; and with a membrane of a beautiful purple color, which serves as a sail. These zoophytes are met with in great numbers in the Atlantic Ocean, and most especially in its warmest regions and at a great distance from land. In calm weather, they float on the surface of the sea, rearing their purple crests, at first looking like large air bubbles, but distinguished by the vivid hues of the tentacles which hang down beneath them. Nothing can exceed the beauty of the spectacle presented by a large fleet of these animals quietly sailing in the tropical seas. Whenever the surface is ruffled by the slightest wind, they suddenly absorb the air from their vesicles, and thus becoming specifically heavier than the water, instantly dive into the depths of ocean.

The *actinia* are a tribe of zoophytes, which are included among the polypi, and are the most highly organized of that class. When their tentacles, which surround the mouth, and are very numerous, are fully expanded, these animals strikingly resemble many flowers, and have been called sea-sunflower, sea-marigold, and sea-carnation. Actinia are seen in great numbers on many shores, adhering by their flat surfaces to the rocks, and being permanent in their abode. When the weather is fine and the sea calm, it is very amusing to watch the rapid expansions and retractions of their many-colored tentacles, while they are seeking food,—the quickness with which they seize their prey when they find it; and to notice the suddenness with which they collapse in a round contracted mass on receiving the slightest injury. They are capable of seeking another abode by a slow, progressive motion.

§ VII.—Echinodermata.

The next in the scale is the echinodermata, which include the star-fish. These animals retain the radiated character of zoophytes. The asterias, or star-fish, so named from its star-like form, with five points, is one of the above. It is covered with a tough coriaceous coating, full of grains. This integument is irritable, and changes its form. The grains are calcareous, and project from the body like prickles. The mouth of the animal opens at the centre of the under side. These calcareous masses have a crystalline arrange-

ment. Each point of the star contains 304 tubes, which terminate on the inside of the body, in a reservoir or bag of fluid, which contracts and propels the foot,—that acts as a means of progressive motion, or rather creeping. Besides this, the asterias is capable of bending and unbending each point.

The skeleton of the *echinus*, or sea-urchin, has a spheroidal form, like the orange. The calcareous material composing it consists of hexagonal plates, curiously fitted or dovetailed together; the whole arranged like a mosaic or tessellated pavement, and forming a very beautiful piece of mechanism. It is covered with calcareous tubercles, arranged with beautiful regularity of symmetry, passing like meridian circles from the upper to the lower poles of the sphere.

The *crinoidea*, or lily-shaped tribe, consist chiefly in the addition of a jointed stalk, which proceeds downwards from the centre, and the branches are carried up and folded inwards. It resembles liliaceous plants. Only two species of this animal are known in a living state: but many are found fossil.

All the species of animals hitherto considered are aquatic, or live in the water exclusively.

§ VIII.—Mollusks.

The mollusks (from *mollis*, soft) in general constitute an assemblage of beings which was recognized as constituting one of the primary divisions of the animal kingdom by Cuvier. A vast multitude of species, possessing many remarkable physiological characters, are comprehended in this class. In all, there is a body of soft consistence, which is enclosed more or less completely in a muscular envelope called the *mantle*, composed of fibres that are contractile, interwoven with the soft and elastic integument. Openings are left in this mantle for the admission of the external fluid to the mouth and the respiratory organs; and also for the occasional protrusion of the head and foot, when these organs exist. Many of the aquatic species are protected by a heavy shell. The oyster, the muscle, and the limpet, belong to this class; and are so stationary that they adhere to rocks at the bottom of the ocean, and depend for nourishment upon food brought them by the currents and waves. Mollusks are divided into three classes—*acephalans*, *cephalopods*, and *gasteropods*.

§ IX.—Acephalans.

This class includes a large number of mollusks, which are destitute of a head, (whence the name—*acephala*, headless,) and have the

mantle elongated to form tubes of much length, to conduct water into the interior of the body. One well-known subdivision of the acephalans are the lamelliobranchiates, or bivalve shell-fishes, such as the oyster, muscle, and cockle. The oyster has the power of locomotion, which is effected by suddenly closing its shell, and thereby expelling the water with force, which, by the reaction of the fluid in the opposite direction, gives a sensible impulse to the mass. Oysters attached to rocks which are occasionally left dry by the retreat of the tide, always retain within their shells a sufficient quantity of water for respiration, (as this is the element in which they breathe,) and then keep their valves closed till the tide returns; whereas those oysters taken from the depths of the ocean, and exposed to these vicissitudes, improvidently open their shells, and by allowing the water to escape, soon perish. The young oysters rove about in the water till they attain their growth, when they fasten themselves to a rock and become stationary. The pearl oyster comes to perfection only in the tropical seas.

Many bivalve mollusks are provided with an instrument shaped like a leg and a foot, which aids their motion; it is constructed much like the human tongue. That of the eatable muscle can advance two inches, and is then applied to some object. The *pinna marina*, or marine muscle, when inhabiting the shores of tempestuous seas, is furnished with a curious apparatus for withstanding the fury of the surge. It prepares a great number of threads, which are fastened to the adjacent rocks, and then tightly drawn by the animal, just as a ship is moored in a harbor to resist the buffetings of the storm. These threads are composed of glutinous matter, prepared by a particular organ, and cast in a mould, where they harden and acquire consistence before they are used. The glutinous secretion is poured into a groove, or canal, in the foot, and when ready, is thrust out on the foot and applied to the object. Thread after thread is thus formed and thrown out all around the shell, on which the animal swings itself round to try their strength, first one and then another. When once they are fixed, being strong and glutinous, the animal has not the power of breaking them. Reaumur, who discovered these interesting facts, saw them practising this faculty when the shells were not larger than a millet-seed. In Sicily, and other parts of the Mediterranean, these threads have been made into gloves, and other articles, which, when manufactured, resemble silk. The shell is of a very brittle texture.

The tellina is remarkable for the quickness and agility with which it can spring to considerable distances, by folding the foot into a small compass, and then extending it, while the shell is at the same time closed with a loud snap.

§ X.—Cephalopods.

This class have a head, which is situated between the body and the feet, whence the name—*cephalopoda*, head-footed. They are higher in the scale of organization, and have a wider range of faculties than the acephalans. To this class belong the loligo, sepia, ink or cuttle-fish, which is furnished with tentacles so powerful that while their muscular fibres are contracted, it is easier to tear away the substance of the limb than to release it from the grip of the tentacles. These are always in the head, and assist the animal in swimming. The head is always downward, and the body upward, so that it walks through the water on its head. The tentacles are long, slender, and flexible, contractile in every part, and capable of being moved or twisted in every direction, with extraordinary quickness, and precision. They twine round an object of any shape, and grasp it with prodigious force, which renders them very formidable.

In addition to these properties, they derive a remarkable power of adhesion to the surfaces of bodies, from their being furnished with numerous suckers all along their inner sides. Each of these is supported on a narrow pedicle, and strengthened by a cartilaginous ring, resembling an ancient boss, or shield-knob, composed of a great number of long pieces, in the form of converging radii, with an aperture in the centre. It has also two long fins; and is further provided with a peculiar internal weapon, or mode of defence, consisting of a bladder-shaped sac, near the tail, which contains a black and viscid ink, which, when pursued by its enemies, it ejects, and thus at once darkens and renders nauseous the water around it, so that it is effectually concealed. It is a dense fluid, about the consistence of pap, suspended in the cells of a thin net-work that pervades the interior of the ink-bag. This ink is called sepia, and is used by artists in painting landscapes, etc. It was used in ancient times instead of ink.

Another remarkable animal of this class is the nautilus, which inhabits a spiral-chambered shell. That of the argonaut, or paper nautilus, is exceedingly thin, and almost pellucid, probably for the sake of lightness, being intended to serve the purpose of a boat. To enable the animal to avail itself of the impulse of air, while thus floating on the water, nature has furnished it with a thin membrane, attached to two of the tentacles, so that it can be spread out, like a sail, to catch the light winds, which waft the animal forward.* While it is sailing, the little navigator plies its tentacles as oars, on each side, to direct, as well as hasten its progress. No sooner does the breeze

* "Learn of the little nautilus to sail,
Spread the thin oar and catch the driving gale."

freshen, and the sea become ruffled, than the animal hastens to take down its sail, and quickly withdrawing its tentacles within its shell, renders itself specifically heavier than the water, and instantly sinks to more tranquil regions, below the surface.

The common nautilus inhabits a polythalamous, or many-chambered shell; and it has a similar sailing apparatus. The animal, at certain periods of its growth, finding itself cramped in the narrow path, draws up the mantle, and leaves a vacant space. The surface of the mantle, which has receded, begins directly to secrete calcareous matter, which is deposited in the form of a partition, across the area of the cavity. As the animal grows, the same expedient occurs. This process is repeated at regular intervals, and produces the multitude of chambers contained in polythalamous shells, of which the living animal occupies only the largest, or that which continues open. The tube which forms the foundation of this shell, is called *syphon*.

All these tribes, and indeed, the greatest number of all mollusks, are limited, by the constitution of their system, to an aquatic existence.

§ XI.—Gasteropods—Formation of Shells.

This class is furnished with a muscular projection from the stomach, which enables them to creep; and hence, the name, *gastero-poda*—stomach-footed. The mollusks which inhabit univalve, or turbinated shells, belong to this order. The projection just mentioned, which performs the office of feet, is a broad expansion of a fleshy substance, occupying nearly the whole under surface of the animal, and forming a flat disk, capable of being applied to the plane along which it moves. The snail is the most striking example. A mucilaginous secretion exudes from the disk, and increases its power of adhesion. In the patella, or limpet, this adhesion is greatly favored by the conical form of the shell, which, having a circular base, enables the muscles of the disk, by their efforts to create a vacuum underneath it, to command the whole hydrostatic pressure of the water, as well as the atmosphere above. Tubular tentacles, which the animal thrusts out, act as feelers.

The formation of shells was discovered, by Reaumur, to be effected by the successive additions made to the surface; and, that the materials constituting each layer, are furnished by an organized, fleshy substance, which is called the mantle, or skin. The calcareous matter which exudes from the mantle, is at first fluid and glutinous, but soon hardens into the dense substance of the shell. This is composed chiefly of carbonate of lime, which is either agglutinated by a liquid animal *cement, into* a dense substance, resembling porcelain,

or deposited in a bed of membranous texture, having the properties of a solid and elastic plate.

This explains the laminated structure possessed by the oyster, and many others, the layers of which are put together like the component leaves of a sheet of pasteboard. The connection between the animal and the shell is merely mechanical, after it is formed.

The natural arrangement of shell-fishes is often subverted by vessels, transporting them from one part of the world to another. It is in this way that the waters of Holland have been peopled by the teredo navalis, which is so destructive to vessels.

The calcareous secretion of zoophytes is a rock, or stone, the moment the animal dies. But the calcareous secretion of testaceous mullusks forms rock only when decomposing. The structure of corals and madrepores is grained, or granulated; while that of shells is lamellated, or stratified.

§ XII.—Articulates—Worms.

M. Agassiz divides this group into three classes,—*worms*, *insects*, and *crustaceans*. The group is distinguished by having the body symmetrical: there is no difference between the right and left side, as is common among the mollusks; and the radiated structure of the zoophytes entirely disappears.

Worms are composed chiefly of a great number of softish rings, forming a cylinder. They are simplest in structure, and least interesting of the group; and therefore, they offer little to detain us, in a cursory survey like the present, although hardly any class of animals offers a greater variety of structure. The *helmins*, or intestinal worm, for instance, contains no heart, no blood-vessel, or even blood, while other worms contain three pairs of hearts, very complicated blood-vessels, and blood of the most ruddy color. The helmins is frequently found in such situations, that it has been generally thought it originated where it was found, by spontaneous generation: but recent researches have shown, that this opinion is erroneous. Most intestinal worms are produced from eggs, swallowed with the food; and in some cases, they bore through the flesh of the animal, within which they are found, until they reach the place where they fix themselves. All the larger animals, from the shell-fishes up to the elephant and the whale, are apt to be troubled with these parasites.

Worms are by no means so unimportant as they at first sight appear: thus, the *lumbricus*, or earth-worm, fertilizes the soil, by converting partially decayed organic matter into a substance capable of being dissolved in water, and nourishing plants. The surgical value

ches is well known; and the depletion such animals produce, ir natural situations, is often the reverse of injurious.

§ XIII.—Insects.

is class contains more species than are found in all the animal om besides. They are distinguished by the absence of a heart, ossession of *antennæ*, or feelers, and of a complex ramification -tubes, which permeates the whole body, and whereby the blood erialized. These generally communicate with the external air ws of orifices along the sides. Insects are generally furnished more organs than the animals previously considered, and are for the variety and rapidity of their motions. Some live in 'ater during their whole lives; others, like the mosquito, spend the first term of their existence in the water.

e most striking peculiarity of insects is the changes they un- during their growth. They are all at first in the form of worms, they are termed *larvæ*, or caterpillars. In passing from this they lie inactive for some time, without taking any food, en-l in a transparent covering, which is often lustrous, whence an ; in this state is called a chrysalis, or aurelia, (from *chrysos* and *m*, both meaning gold.) From this state they pass into that of erfect insect. Most insects live on vegetable food; but some are vorous; and others are at first carnivorous, and afterwards phy-ous, or plant-eating.

e strength of insects, compared with their size, is frequently as-ing: thus, the *lucanus cervus*, or stag beetle, has been known aw a hole, one inch in diameter, in the side of an iron canister, ich it had been confined; and the *geotrupes stercorarius*, or l-born beetle, can raise a weight 500 times heavier than its own .

is in the midst of the most exuberant vegetation,—in the torrid for example, that the strongest and most splendid insects are such as the butterflies of Africa, the East Indies, and America, e brilliant colors rival the lustre of metals. There, and particu- in South America, the forests, peopled with millions of glow-s, look like an immense conflagration. The *termes* of Africa, d also, the white ant, builds solid hillocks; and the spider of na, attacks even birds with success. The *limulus gigas*, the st of all aquatic insects, is also an inhabitant of the equatorial ns, as its usual name,—crab of the Moluccas,—indicates.

rtain kinds of insects, such as gnats, bees, ants, and flies, appear equally distributed over the whole globe. The short polar ner hatches a multitude as innumerable as the heats of the tor-

rid zone. The mosquito which torments the traveller on the banks of the Orinoco, is the same as that which buzzes in Lapland. Wherever man has not drained the marshes, and cleared the forests, insects reign with resistless sway. History has recorded several examples of towns and countries being rendered uninhabitable by the multitude of bees and wasps, or gnats. Armies and whole tribes have been forced to fly before these feeble insects, invincible by their numbers. The ravages of the locust in the East have been very familiar to the inhabitants from the earliest times, and are frequently alluded to in the Bible. They frequently desolate whole provinces, devouring everything green: but the inhabitants retaliate by gathering them and laying them up for food. The locust is one of the few insects permitted to be eaten by the Mosaic law. (See Leviticus xi. 22.)

Insects offer so much that is interesting to our observation, that rather than dwell further on the subject, we refer our readers to Kirby and Spence's *Entomology*, a work which will gratify their curiosity regarding the structure, polities, architecture, transformations, stratagems, wars, and affections, of this remarkable class of animals.

§ XIV.—Crustaceans.

This is the highest class of all invertebrate animals. They are covered with a hard crust composed of several jointed pieces, whence their name, and are furnished with a complete circulatory apparatus, including a heart, blood-vessels, and branchiæ, or gills, which answer the same purpose as the lungs of the higher animals. The lobster, crab, shrimp, and horse-shoe, are the best known specimens of this class. The power of reproduction among them, is much more extensive than among the higher animals. Thus, we frequently see a lobster with one claw much smaller than the other. In this case, the smaller one is a second growth, which had not yet attained its full size, the animal having lost the original claw by some accident. The eyes of the crustaceans, like those of insects, are very complicated, consisting of an immense assemblage of eyelets placed side by side, so that the animal can see in any direction without moving the eye, for which, indeed, there is no apparatus. Some species have as many as ten thousand of these eyelets united to form the hemisphere of the eye. Crustaceans are found in almost every sea, but abound most in tropical and warm regions.

§ XV.—Vertebrates—Fishes.

Vertebrates are distinguished from the three preceding classes of animals by possessing a brain, and a spinal chord, enclosed in a bony covering, and having the organs of vegetative life—the heart, lungs, and digestive apparatus—in a separate cavity. They are divided into four classes, viz.: *fishes*, *reptiles*, *birds*, and *mammals*.

Fishes are distinguished by possessing branchiæ, or gills, instead of lungs, which enable them to procure the little oxygen they require from the small bubbles of air always contained in ordinary water, whether fresh or salt. It is for this reason that a fish preserved in a vase requires to have the water changed, because, after a while, the oxygen of the air bubbles is all consumed. A fish may be drowned by placing it in water that has been well boiled, as this completely removes the air. Fish require comparatively little oxygen, because they are cold-blooded, and are covered with water, which is a bad conductor of heat. The water they take in at the mouth, passes off through the gills, and is in the meantime brought into immediate proximity with the blood circulating through the gills, which absorbs a little of the oxygen, and returns a little carbonic acid. They are further distinguished from the higher animals by having the nasal cavity, or nostrils, opening outward only, and not communicating with the mouth. The heart is single, consisting of one auricle and one ventricle; and they are furnished with a covering of scales, which is protected from the action of the water by a slimy secretion. They generally propel themselves by means of the tail, and steady and steer their course by means of the other fins. Some fishes, however, are destitute of such appendages, and creep along the bottom of the sea. Most fishes are carnivorous, and many live on animalcules. The best eatable fishes, such as the salmon, cod, herring, and mackerel, are found in shallow water.

Every basin of the ocean, and generally every sea, and even lake, has its particular tribes, which are born and die there, without transmigration. We know the stations of some fishes. Thus, the cod, which fill the northern seas, between Europe and America, congregate on the great sand-banks south-east of Newfoundland, where they are pursued by 20,000 fishermen. Yet in spite of the destruction attending this race, they increase with such amazing rapidity as to supply all deficiencies. It is calculated that one codfish could produce nine millions of young ones, though it is not probable that one tenth of that number is ever actually produced.

The *coryphenæ* and several other genera are met with only in the torrid zone. There are various species of these which are called

gilt-heads, from their brilliant colors. They are found only between the tropics. They are observed both in the Atlantic Ocean, and in the Indian Ocean.

The electric fishes are chiefly confined to the torrid zone. The electric *gymnotus* is confined to America; and the trembler, or *silurus electricus*, to the rivers of Africa; but the *torpedo*, or cramp fish, is dispersed over all the seas.

The migration of fishes is occasioned by their being impelled to seek shallow water to deposit their spawn. Thus the herrings, coming from the depths of the frozen sea, proceed every year to the coasts of Ireland, Scotland, Norway, Sweden, Denmark, Holland, and the United States, and to Kamschatka, and the neighboring islands. It has been proved that immense shoals of these fishes follow mechanically the direction of the chains of submarine banks and rocks which they meet with in their progress. Tunnies migrate annually from the Atlantic to the Mediterranean. The currents of the ocean occasion other migrations besides the annual ones. The observations of Biot and La Roche, by demonstrating the admirable property of the organs of respiration in fishes, by which they can inhale the more oxygen the lower they descend, seem to remove all limits to the migrations of species which live in the lower parts of the sea; and in fact, the very same species have been found both in the Arctic and the Antarctic Ocean. As we cannot suppose they could stand the high temperature near the surface of the tropical seas, during their migration, we must suppose that they passed from one region to the other at a great depth.*

The fishes of lakes and rivers are not susceptible of any accurate geographical classification. The kinds *cyprinus* and *perca*, or carp and perch, people all the rivers of the temperate zones. The sturgeon is found in the smaller inland seas, such as the Baltic, Caspian, and Black Seas. The larger species, common in the Volga and Danube, are in their turn surpassed by the silurus glanis, the giant of river fish. The voracious pike often inhabits subterranean seas which communicate with the atmosphere only by small openings, and so do some other species.

There are some fishes which occasionally forsake their native elements. Eels cross meadows, and on the coast of Coromandel, a kind of perch, called perca scanderus, climbs up the palm trees. Sonnerat observed fishes that lived in warm springs of a very elevated temperature.

* Live animals have been taken up from a depth of 1000 fathoms; and it is possible that some may be found still lower.

§ XVI.—Reptiles.

Reptiles are distinguished by possessing a heart with three cavities, two auricles, and one ventricle, a structure intermediate between that of fishes and mammals. They are also cold-blooded, like fish, and generally slow in their motions. Their power of digestion is extremely slow; hence some of them can live for years without eating. Their sensations are obtuse; and they all spend a part of their lives in a torpid state—in cold regions, the winter, and in hot regions, the dry season. The circulation through their lungs is so feeble that respiration can be completely suspended without arresting the general circulation of the blood. Some of them, as the turtle and the alligator, continue to live and exhibit apparently voluntary motions after losing their brains; but it is doubtful whether the motions then performed are not of a reflex or mechanical nature exclusively. They are mostly oviparous, but never hatch their eggs.

Reptiles are divided into five classes, viz.:—1st. *Rhizodonts* (root-toothed,) those having teeth with roots, and being covered with scales, as the crocodile and the alligator. 2d. *Saurians*,* or the lizard tribe, which have the teeth united to the jaw, without any root. To this class belong the common lizard and the chameleon. 3d. *Ophidians*,* or the serpent tribe, which can move the jaws sideways, as well as up and down, whereas lizards are capable only of the latter motion. To this class belong numerous well-known species, from the great boa-constrictor to the garter-snake. 4th. *Chelonians*,* or the turtle tribe, including the various kinds of turtle and tortoise. These are distinguished by being protected both above and below by a hard, bony cuirass, under which they can draw head, legs, and tail, in times of danger. 5th. *Batrachians*,* or the frog tribe, including all kinds of frogs and toads. These are distinguished by having a soft, naked skin, and possessing gills like fish during the early period of their existence, which some species retain through life. The whole number of species of reptiles known exceeds 1,000.

A few reptiles are found in cold regions; they are numerous in temperate climates; but they are most abundant within the tropics, where most of the largest species are found.

Of the rhizodonts, the principal are the gavial of India, the crocodile of Africa, the alligator of the United States, and the cayman of South America. The order was much more numerous in former periods than it is at present. The same is true of the saurians, which are not only less numerous, but much smaller than those of the tetrazoic period. They generally have four feet, although some species

* These terms are derived from the ordinary Greek names;—*sauros*, a lizard—*ophis*, a serpent—*chelus*, a tortoise—and *batrachos*, a frog.

have none, while the ophidians have no feet, except a few species, which have rudimentary feet. All the saurians have a long, thin, forked tongue, like snakes. One of the most remarkable is the dragon, found in India, an animal very different from that known in nursery tales and heraldry. It is a lizard, supplied with two membranes running from its fore to its hind legs, something like the wings of a bat. These do not enable it to fly, but only assist it in leaping from bough to bough, in pursuit of insects. It is as harmless as the common lizard. One of the largest of the order is the iguana of South America, which is about five feet long. It is exclusively herbivorous, and reckoned very fine eating.

It is a common opinion that all the serpent tribe are poisonous, whereas in reality hardly one fifth of the various species, and none of the largest, are so. Those which are poisonous have movable hollow teeth, uniting with the sac containing the poison, which is injected into the wound through the tube in the tooth. The most remarkable of poisonous snakes, are the asp of Egypt, the hooded snake of India, and the copper and rattle snakes of America. There are several species of sea-serpents, which live exclusively in salt water, and are all poisonous. Some serpents live chiefly in trees; these are found within the tropics, and chiefly in South America. The boa-constrictor of that country is the largest of all the ophidians, being found thirty feet long. It is capable of swallowing whole the carcass of a horse or cow. The largest snakes of the Old World are the pythons of Asia and Africa, the largest of which is twenty feet long. These are sometimes called boas; but they are different from the American boas. When these large species have swallowed a carcass, they are very slothful, and slow in their motions, so that they are killed without danger or difficulty.

The chelonians are confined to temperate and warm regions, the larger to the latter exclusively. Europe contains only a few of the smaller kinds. They abound in Africa, Malaysia, the United States, and South America. Some live on land exclusively, and some are amphibious. Some large species are found in the West Indies; and the largest of all the order, is the turtle of the Galapagos, which sometimes weighs upwards of 500 lbs.

The batrachians are noted for undergoing a metamorphosis, similar to that of insects. When first hatched, they have the appearance, and lead the life of fishes, breathing only water. After a while, legs are seen protruding from their sides; the gills and tail become atrophied and disappear, although in some species they continue during life, and no legs appear. In every case, however, they emerge from the water, and henceforth chiefly breathe air. In their first condition, they are known as *tadpoles*, termed in some parts *porwiggles* or *polliwogs*.

The batrachians are most abundant in America, and least so in Europe. In Polynesia, none have ever been discovered. The largest of the order is the *bufo agua*, or Brazilian toad, which is about a foot long. Frogs are the most numerous genus of reptiles, there being upwards of 100 species known. Of toads there are scarcely one third of that number. Of batrachians that retain the tail through life, the most remarkable is the salamander, or evet. This animal, in common with all batrachians, has a great power of resisting the influence of external heat, on account of a rapid evaporation from the skin, and its power of retarding respiration without stopping the circulation of the blood. Hence, probably, arose the story that it could live in the fire, which is a mere fable.

§ XVII.—Birds.

Birds are very uniform in structure, and therefore require only a brief description. They differ from all preceding classes, and agree with mammals in being warm-blooded, having a double heart, and the brain much larger in proportion to the size of the body. That of the sparrow, for instance, is half as large as the brain of the Galapagos turtle. The great peculiarity in the structure of birds is, that the anterior extremities are wings, instead of legs or arms, although the bones in the wings are quite similar to those in the fore legs of quadrupeds. They are further distinguished by the mouth terminating in a bill, without teeth, and the body being covered with feathers, and the feet and claws with scales. They differ from all mammals, and agree with the lower classes in being oviparous. To render them light, they are furnished with a large air-sac, which extends from the lungs into the abdomen and the bones, so that the latter (which are very thin besides) are filled with warm and consequently light air, instead of marrow. More than 6,000 species are known. They are divided into five orders:—1st. *Raptores*—birds of prey. 2d. *Insessores*, or perchers, which includes most of the small birds. 3d. *Rasores*, or scrapers, including the common hen, turkey, partridge, grouse, pheasant, &c. 4th. *Grallatores*, waders, such as herons and snipes. 5th. *Natatores*, swimmers, such as ducks and geese. These orders are distinguished by the structure of their feet, and a corresponding form of the beak. America contains more species than any region of the old continent; and Europe exhibits more than either Asia or Africa. The most beautiful birds are found within the tropics; but the sweetest singers are natives of the temperate zones. Some birds are found all over the world, especially sea-fowls, while others never go beyond certain narrow limits. Thus the condor, and the king of vultures, never forsake the Cordilleras of

Peru and Mexico. The European vulture and great eagle, never remove from the ridges of the Alps, while the sea eagle, or ospray, is distributed over the whole globe. The paroquets, common in America, are exclusively found in the torrid zone; the cockatoos are found only in the East Indies; and lories, most beautiful birds, in the islands south-east of Asia. The celebrated bird of paradise is never met with beyond the limits of a very narrow region of the torrid zone, viz.: New Guinea and the neighboring islands. Of birds which cannot fly, every equatorial region, insulated by the sea, has produced particular kinds. The ostrich, of Africa, the cassiowary, of Java, and of New Holland, and the toucan, or ostrich of Brazil, exhibit, in very distinct species, the same general features of organization. They are all distinguished by a flat breast, small wings, and downy feathers. Though unable to fly, they run with amazing velocity, the ostrich, for instance, sometimes going at the rate of 100 miles an hour.* It can be caught only by tiring it out by means of a relay of horses. The smaller birds in the tropical countries are adorned with the most splendid colors, and their plumage vies with the metallic brilliancy of the insects of the same zone, while it is much more varied.

The temperate zone of birds reaches, in the eastern hemisphere, from the 30th to the 60th parallel. Within these boundaries the various genera, and even some species, are no longer confined to regions distinctly marked, and have no particular fixed countries. Several species have followed the footsteps of man, as he removes to distant countries; either by force or naturally. The mocking-bird, for instance, is said to follow civilization.

The most remarkable geographical phenomenon in the history of birds, is the annual migration of many species, including swallows, martins, wild geese and ducks, storks, cranes, &c. These, (which are termed birds of passage,) at the approach of winter, abandon the colder climates, to spend the winter in warmer regions. Some species of swallow were formerly supposed to plunge themselves into lakes and marshes, and there remain in a dormant state during the winter: but such an opinion is entirely without foundation, and could have obtained general currency only when the difference between birds and reptiles was not well known; for, owing to their vigorous respiration, it would be more difficult for birds to live in such a situation than for men.

The frozen zone has few species belonging to it: among them is the *anas mollissima*, whose nests furnish the eider-down. But we should consider this aquatic bird as only frequenting the shores of the frozen seas. The *strix lapponica*, or Lapland owl, and the *tetrao*

* "What time she lifteth up herself on high, she scorneth the horse and his rider."—JOB, xxxix. 18.

lagopus, or tarmachan, live upon high, cold mountains. The latter becomes so white in winter, that it is difficult to observe it on the snow; while in summer it is more brown than white, and then is not easily noticed among the heath.

Every great maritime division of the globe has its peculiar birds. The albatross flits along upon the waves, as soon as we approach the 40th parallel of latitude. The sea-swallows and tropical birds never forsake the torrid zone. Eagles and hawks are found in most parts of the world; and North America presents us with a great variety of species. Here also is found a great number of various kinds of owl. The immense family of the humming-birds is wholly American, most of the species being found in the warm regions of this continent, though some are seen as far north as Canada. These are all distinguished for the extreme beauty of their form and plumage, the smallest species (which is not larger than a wild bee,) looking altogether like a creature of the imagination. America contains more birds of passage than any other part of the world; and the immense numbers in which they migrate, is almost incredible. The speed with which they fly is equally astonishing: wild pigeons have been known to go 500 miles in a single day. On the western coast is seen the white albatross, one of the largest and most powerful of birds. It often measures 14 feet from tip to tip, and can fly a whole day without alighting. This is the native country of the turkey, which is still found wild in the forests, where it attains a size and beauty surpassing anything which it exhibits in the farm-yard.

Many North American species are identical with those found in Europe; but those of South America mostly differ from all the rest of the world; and that country contains many more species than any other. There are upwards of 1,000 species of perchers peculiar to it. The condor, or *vultur gryphus*, may be seen flying four miles above the sea-level. This bird is among the largest of the raptores, although its size was long exaggerated. It is killed with great difficulty, since its feathers resist even a musket ball, unless closely fired. It lives on carrion. The largest and fiercest of the eagle tribe is the *aquila destructor*, or destroying eagle, found in Guiana and Brazil.

Europe seems to be the native country of the domestic duck and goose, where they are still found wild. The red grouse, or heath-cock, of Britain, is peculiar to that island, on whose mountains they are shot in myriads every autumn. The white grouse, or tarmachan, is found in Scotland and Scandinavia. In Britain, also, is found the *tetrao tetrix*, or blackcock, a large and beautiful bird of game. The capercailly, or *tetrao urogallus*, is now found only in Scandinavia, although formerly common in Britain. Partridges abound throughout Europe. Of its rapacious birds, the most notable are the golden eagle, found through western and central Europe, the lemmergeyer, a

species of vulture, found in the Alps and Pyrenees, and the falcon, or blue hawk, formerly much used in hawking. This bird is now found only in north-western Europe.

South-eastern Asia and the adjacent islands are noted for the beautiful plumage of its birds, though few of them equal the dazzling and varied lustre of some humming-birds. This seems to be the native country of the domestic hen; and wild peacocks are still found in India. When we pass to Australasia, the birds become peculiar.* Some of the most remarkable species, however, appear to be extinct: the *dinornis giganteus* (terrible gigantic bird,) of New Zealand, was about 12 feet high,—much larger than any ostrich. In Australia are found black swans, and white hawks. The *tui*, or parson-bird, a native of New Zealand, is a better mimic than any parrot, and can be taught to repeat whole sentences. It is of a jet-black color, with a white tuft on the breast.

To Africa we owe the guinea fowl, throughout which it is still found wild. Many species of grouse and partridge are peculiar to this quarter of the world. The ostrich is found in its northern parts, and in Arabia.

§ XVIII.—Mammals.

Mammals resemble birds, in possessing warm, red blood, and a double heart: but they differ from them and all other classes of animals, in being viviparous, and suckling their young, whence their name—from *mamma*, a teat. They include most of the large animals, and all the more sagacious: they are distinguished by a more complex organization than those already considered, and by exhibiting more of those affections which are so fully displayed in man; so that they are at once more intelligent, and possessed of more varied and permanent feelings than any other class of animals. This, combined with their immense utility to mankind, gives them a degree of interest far superior to that which attaches to such animals as sponges or polypes, or even to kites and crows. Hence the masses of mankind feel much more interest regarding them: and their habits and characteristics were closely observed, when yet the best informed naturalist could not positively say whether the polypi were plants or animals, or whether the crab was a fish or a beast. It was only recently, however, that they were classified according to their real affinities; and the classification of Aristotle, made about 2,200 years ago, is considered, by competent judges, superior to any that succeeded it, till the celebrated Cuvier, in our own day, arranged

* Australasia may be said to have a peculiar set of organic beings, both plants and animals; and many of the latter appear to us very singular.

them in a manner so satisfactory, as to supersede all former divisions. His classification is essentially adopted by Professor Owen, of London, one of the most distinguished of living zoologists, who divides all the mammals into 12 orders. These are given below, beginning with the lowest.

1st. *Monotremes*, whose alimentary canal terminates like that of birds. Of this order there are only two genera, both Australian. One is the *ornithorhynchus*, (bird-beaked,) which has the bill of a duck, and otherwise resembles a mole: whence it is termed the *water-mole.* The other genus is the *echidna*, a kind of ant-eater, with spines like a porcupine. The males of both genera have the hind foot armed with a curved spur, which is hollow, like a viper's fang, and has a poison-sac at its root.

2d. *Marsupials*, (pouched animals,) where the female has a part of the abdominal integument folded inwards, so as to form a bag, in which the young are carried for a time after they are born, or shielded from danger. The best known of this order are the opossum, wombat, and kangaroo.

3d. *Rodents*, (gnawers,) which have two long chisel-shaped incisors, or cutting teeth, in each jaw, with no canine teeth. To this order belong mice, rats, hares, squirrels, rabbits, beavers, porcupines, and guinea-pigs.

4th. *Edentals*, (toothless,) where the teeth are more or less imperfect, although they are not strictly destitute of any teeth. The cutting teeth are generally wanting. To this order belong the anteater, sloth, manis, and armadillo.

5th. *Ruminants*, (cud-chewers,) which want incisors in the upper jaw and have a complicated stomach of four cavities, so disposed as to allow the food, after being first swallowed, to be returned into the mouth for thorough mastication and insalivation. This order is large and very important, including the ox, buffalo, bison, sheep, goat, chamois, the various kinds of deer, elk, and antelope, the camel, lama, and camelopard.

6th. *Pachyderms*, (thick-skins,) which are distinguished by the great thickness of their hides and their solid hoofs. This order includes the horse, ass, zebra, hog, rhinoceros, elephant, and hippopotamus.

7th. *Cetaceans*, (whale tribe,) which are distinguished by the posterior extremity terminating in a fishy tail, which, however, is horizontal, and not vertical, as in all fish: the anterior extremities are so formed as to answer the purpose of paddles; and they have a large nostril or two on the upper side of the head. The order includes the largest of all animals,—the most important being the Greenland or right whale, cachalot, or sperm-whale, grampus, manatee, dolphin, and porpoise. The whole order is gregarious. They

are popularly confounded with fish, because they live in the ocean; but as they have a double heart, with warm, red blood, breathe air (not water, which all true fish breathe) and suckle their young, they are by all naturalists classed with mammals; and they are no more fish than seals or otters. They are protected by a thick layer of fat from the effects of a too rapid escape of heat by evaporation when they are above water, or convection when below.

8th. *Carnivorans*, (flesh-eaters,) which have cutting teeth in each jaw and two long and pointed canines, with sharp molars, adapting them to destroy living prey, and devour the flesh: the extremities are furnished with claws, for the same purpose. The order is very large, and some of the species are the most formidable of the animal creation. The principal are the lion, tiger, leopard, panther, cougar, or puma, jaguar, cat, lynx, hyena, bear, wolf, dog, fox, jackal, weasel, walrus, and seal.

9th. *Insectivorans*, (insect-eaters,) which have small sharp points on their molar teeth, enabling them to devour insects. The order is small, the mole, shrew, and hedgehog, being those best known.

10th. *Cheiropterans*, (hand-winged,) which have the anterior extremities furnished with long fingers, connected by a membrane, which serves the purposes of a wing. Bats and vampires are the principal genera.

11th. *Quadrumans*, (four-handed,) which have the four extremities terminated by hands. This order is very extensive, including the numerous tribes of the ape, monkey, baboon, and lemur.

12th. *Biman*, (two-handed,) where the upper extremities terminate in hands, while the lower are so constructed as to furnish a steady support, without any assistance from the upper. This order contains man, who stands in it alone. Unimportant as the above peculiarity might appear, it is in reality one of the most important physical advantages that the human structure possesses over those of the lower animals: for the possession of a heel, strong lower limbs, and a body balanced upon them,—all of which are peculiar to man,—enable him to employ his hands freely, without being obliged to employ them in maintaining an upright position. All the quadrumans naturally stoop, and are obliged to employ the upper extremities for permanent support: hence they could not perform any nice or complex manual operation, even if they could contrive it. The human system possesses several other advantages over that of the most elevated of the lower animals; but the preceding will suffice as a distinction. It is in his mind, however, that we find man's incomparable superiority over the highest of the brute creation. About the end of last century, Helvetius defended, at some length, the paradox that man's superiority was dependent solely upon his hand, and that he did not differ psychically from the lower

animals. It is, no doubt, very true that the human hand is very superior to that of a quadruman: yet the single remark of Dougald Stewart refutes the whole of Helvetius' argument: monkeys warm themselves by a fire left by travellers in the wood; but they never have the sense to throw on a stick to prevent it from going out, though their hands are very competent for that purpose. Much less have they ever kindled a fire. Another fact shows that man owes more to his mind than to his physical superiority: his hands are often so injured by accidents as to become decidedly inferior to those of the baboon; yet he still produces pieces of mechanism and performs operations which no quadruman ever attempts, much less effects. Socrates, therefore, took a much more correct view of the case, more than 2,000 years before Helvetius was born, when he argued that man's body was adapted to his mind, and an ox's capacity to his, whereas there would have been folly in uniting the psychical characteristics of either to the physical structure of the other. We have introduced man here, simply to show where he stands physically considered. His importance will demand a separate division; and therefore we say no more of him in the present.

The orders above enumerated—which contain more than 1,500 species—are distinguished by many other peculiarities, corresponding with those we have mentioned: but we consider it unnecessary to state them in this work. For a knowledge of these, and of the peculiarities of the various genera and species, we refer to Jones' Outline of the Animal Kingdom, and the works of Cuvier, Grant, and Owen.

§ XIX.—Domesticated Mammals.

In surveying the distribution of mammals, we perceive they may be divided into two classes—those which are found in every part, or at least in most parts of the world, and those which are found only within certain limits. To the former class belong most domestic quadrupeds; and it is remarkable that those most useful to man can attend him through every clime, while difference of circumstances produces endless varieties of the same species. The fleecy sheep, the milk-giving cow, and goat, the powerful horse, the hardy ass, the all-devouring hog, the faithful dog, and even the social and amusing cat, accompany him from the equator to the farthest verge of civilization; and wherever man can flourish, so can they. The horse and the ass are natives of central Asia; but they flourish equally well on the prairies of the Mississippi, or the pampas of the La Plata. The cow is a native of Europe, and northern Asia: but she is equally

productive in America; and sheep flourish uncommonly well in Australia, though they are natives of Asia. There are a few remains of wild cattle still found in eastern Europe, and also in Britain, where occurs the wild-cat, very similar to the domestic variety, but larger and much fiercer. The domestic goat seems to be indigenous to Europe and Asia, where it is still found wild. The hog is found wild in eastern Europe, and northern Asia, at this day.

In the preceding paragraph we spoke only of the domestic species; but many others of the same genus are often found in a wild state. Thus North America contains a species of goat, and another of sheep, found among the Rocky Mountains—the latter larger than any domestic sheep, with immense horns—and the American bison, (generally termed the buffalo,) is only another species of cow. It was formerly found as far east as Connecticut; but the tide of human population has driven it beyond the Mississippi, between which and the Rocky Mountains it is still found in large herds, from 30° to 60° N. lat.* Abyssinia contains another species of ox, with horns four feet long, and seven inches in diameter at the root. The Cape buffalo is another, belonging to the same country. The principal other species is the arnee buffalo, found in India, whose horns are sometimes upwards of six feet long, and half a foot in diameter. It is domesticated through Asia, northern Africa, and Italy. The urus, or auroch, of Lithuania, appears to be the common ox, in a wild state; and the brahminy bull, of India, is only a variety of the same species. The European bison, however, is a different species, distinguished by having fourteen pairs of ribs, while the common ox has thirteen, and the American bison fifteen. The mouflon, a species of sheep, is still found wild in Sardinia and Corsica. The argali, of Asia Minor, the rass and the kuchgar, of Thibet, appear to be all different species of sheep. The kiang, or jiggetai, of Thibet, is another of the horse species. The yellow goat, the shawl-wool goat, and the Tartar ox, of the same country, seem to differ from the common domestic species.

There are many other animals besides those found in a domesticated state, which are found throughout the world. Of these we may mention the fox, hare, wolf, squirrel, weasel, bear, rabbit, stag, rat, and mouse. The latter species were probably dispersed by means of ships. In many cases, however, the species is different, though the genus is the same. Many of the quadrupeds found in the

* We think our agriculturists should try the experiment of domesticating this animal, and also the native sheep and goat. It is very probable they would suit the country better than the imported species. The Marquis of Breadalbane is trying such an experiment with the American bison at Taymouth, in Scotland: but it would be more likely to succeed in the animal's native country.

northern parts of North America, are the very same species as occur in northern Europe, and Asia. The two continents were probably connected at Bhering's Strait; and if not, the ice forms a natural bridge, and sometimes a raft, on which they could pass. We infer that the same species, found in both countries, had one origin, and passed from one continent to the other; because it is only in the case of such as can stand a cold climate, that identity of species exists in the two continents. The large pachyderms and felidæ, such as the elephant, horse, tiger, or lion, are never found specifically the same in the Old World and in the New; and most of the mammals of South America are peculiar. Our knowledge in regard to the distribution of species, leads us to conclude that the same *species* never had more than one origin, though the same *genus* often had several. Asia, Africa, North America, and South America, have all many peculiar species. We never find the same species, except in situations which lead to the supposition that they sprang from a common source.

§ XX.—North American Mammals.

North America contains many species of deer, some of a very large kind. The wapiti, (sometimes called the elk, though erroneously,) resembles the stag, or red deer, but is much larger. It is found in Canada, and along the Rocky Mountains. The stag, or Virginia deer, is found throughout the country, from Hudson's Bay to Mexico. The moose, or American elk, is found in the wilds of Maine, and through the forests, on to the Pacific, but never south of the lakes. This animal greatly resembles the European elk; but it is a different species. The horns sometimes weigh 15 lbs. each. The carabou, or American reindeer, is found in the arctic regions, and down towards the great lakes. The musk-ox is found along the Arctic Ocean; it derives its name from its flesh smelling strongly of musk. The prong-horned antelope is found west of the Mississippi to Mexico.

The American white or polar bear, is the same as that found in northern Europe. It generally lives along the coast, never going far inland, and often passes from place to place on floating ice. It does not hybernate, like other bears. When full grown, it is 9 feet long, and 4½ high, and remarkably strong and fierce. The grizzly bear is found west of the Mississippi to the Pacific, and as far south as Mexico. It is not inferior to the polar bear in strength or size, and is still more fierce. The American black bear is more numerous, but much milder and smaller than the preceding. It is found all over North America, and is omnivorous, devouring roots, berries, eggs, fish, &c. The other two species are chiefly carnivorous.

The puma, or cougar, (sometimes called the panther, and American lion,) is the only formidable animal of the feline race in North America; but it seldom attacks man. It is found throughout the country, from Canada to Patagonia. Wolves, foxes of various species, and wild dogs, are found in all the unsettled parts of the country.

North America is remarkable for its variety of fur-bearing animals, among which the ermine, otter, marten, weasel, and musk-rat, are the most important. These are now becoming scarce, and are found chiefly in the most remote and solitary regions; and the time seems to be near at hand when the "trapper's" occupation will be numbered with the things that were.

§ XXI.—South American Mammals.

South America is much less remarkable for its mammals, than for its birds. Of its beasts of prey, the jaguar, a beast resembling the tiger, is the most formidable. It is found throughout the warm regions, as far as the La Plata. The monkey tribe is extremely numerous, though almost unknown in North America. They are mostly of the smaller kind, the baboons and orangs of the eastern world being unknown: but they are more playful, gentle, and beautiful. The deer species are neither numerous nor important. Marsupials are found, of many species, chiefly opossums. Bears, so common in North America, appear to be unknown. This is one of many proofs that the animals of South America are very distinct from those of the northern continent.

The largest of South American mammals is the tapir, a pachyderm, with a short proboscis, of which there are two genera. The principal ruminants, are the llama, the vicuna, and the alpaca, all of which somewhat resemble the camel; but they are much smaller. They are found only on the Andes. The vicuna produces a fine wool, and the other species are sometimes used as beasts of burden. The llama was the only animal of that kind, possessed by the aboriginal Indians. The edentals are numerous: the principal are the ant-eater, found as far south as the La Plata—the armadillo, protected by a bony covering, found on all the warm plains—and the sloth, which is found only in the warmer regions, where it may often be seen rolled up into a ball, and suspended from the bough of a tree, looking more like a large tuft of moss than like an animal. The movements of its limbs may be compared to the minute hand of a clock. The whole tribe live almost exclusively in trees. Rats and mice are numerous, and of many species, several of which are very peculiar. Upon the whole, the mammals of South America bear a closer resemblance to extinct species, than those of other parts.

The quadrupeds introduced from Europe have greatly changed the fauna of this continent. Now its llanos and pampas are tenanted by immense herds of wild cattle, horses, and asses,—of the finest kind: and among the Andes may be found large flocks of sheep. The possession of the horse and sheep have completely changed the habits of some of the aborigines. Thus the Araucanians of Chili now tend their flocks, and ride on horseback, like so many Toorkmans, whereas, at the discovery of the continent, they were hunters exclusively. The value of these animals they were not slow in appreciating; and they came against the Spaniards with a strong cavalry force only 15 years after they had first seen a horse. They still possess a great part of Chili, and have not been subdued to this day, though often attacked.

§ XXII.—European Mammals.

Europe contains no indigenous quadrumans; and its species of quadrupeds are not very extensive, though very important. Several of these have been already mentioned in speaking of domestic animals. The elk and reindeer are found in its northern parts. The latter is found both wild and domesticated: it constitutes nearly the whole living of the Laplander, who feeds on its flesh and milk, and is clothed with garments made of its skin, sewed with threads of its sinews. It is never found to flourish below the parallel of 60°, in Europe, or the 45th, in Asia; south of this, it gives place to the stag, or red deer, the fallow-deer, and the roe. Of beasts of prey, the principal are the glutton, found in the north—the black and the brown bear, found in central Europe—the polar bear, that never goes beyond the shores of the Arctic Ocean—the wolf and the fox, common throughout the country, and the lynx, now found chiefly in Spain. Many rapacious beasts have now become extinct in many parts, as the lynx in central Europe, and the wolf and the bear in the British Isles. The wolf disappeared there, little more than 100 years ago. The cunning fox maintains his ground almost everywhere. The variety found in the north is larger and fiercer than the Italian, or southern, and often does great damage among the flocks. In the Scottish Highlands, the fox-hunter is a regular paid functionary, whose services are in frequent demand among the shepherds.

The ibex and chamois, animals resembling the goat, are found among most of the high mountain chains, whence they never descend into the plains. The beaver is still found on the large rivers of eastern Europe: there are several species of squirrel; and the otter is common in many parts. The hedgehog is general; and the porcupine occurs along the Mediterranean.

§ XXIII.—Mammals of Asia and Oceanica.

The mammals of Asia are more numerous than those of Europe, but those of northern and central Asia are in a great measure the same, although upwards of 300 species are peculiar. Asia is the native country of the camel, of which there are two species—the Bactrian, or two-humped, which is very strong and hairy, found in central Asia and round the Caucasus, and the common, or Arabian camel, which is one-humped. This species is now common all over northern Africa. Its structure most clearly indicates the countries for which it was designed; its astonishing powers of abstinence from food or drink, its relishing the coarse prickly herbs of the desert, its broad spongy feet, and even its nostrils, (which can close completely on the simoom, or flying dust,) indicate that it was designed for the great deserts. An immense amount of nutriment is laid up in its hump, on which it lives during long journeys; and it is furnished with a fifth stomach, in which it carries water, which is transferred to the paunch as its needs require. The water is preserved in this stomach so sweet that it is common for caravans, when short of water, to kill a camel for the sake of the water bag. It can go without water for more than a week, and smells it at a great distance. It is to the Arab what the reindeer is to the Laplander. The dromedary, or mahairy—which is only a lighter and swifter variety—goes with a single rider about 100 miles a day; and the heavy variety generally carries 800 lbs. at the rate of three miles an hour. The Bactrian camel seems designed for the cold, as the Arabian is for the warm deserts. It is said to be still found wild in Tartary.

Asia abounds with deer and antelopes, there being no less than 20 species of the former, and half that number of the latter. The musk-deer is peculiar, and found on the central tableau. Among the pachyderms are the elephant, now found only in India and the adjacent islands, though formerly found beyond the Indus—two species of rhinoceros, one single-horned and the other two-horned—a species of tapir, found in Sumatra—and the babyroussa hog, found in the forests of the Asiatic Archipelago. The tusks of this animal curve upwards and backwards, and thus serve to defend its eyes in passing through the jungles.

The most formidable of the Asiatic carnivorans is the tiger, which is found south of the Altaian Mountains to the ocean. It is peculiar to this continent. The tiger has the reputation of being the most cruel of all animals, while he is not remarkable for courage. Fights between tigers and wild buffaloes are common amusements in the east, and the despotic rulers of those countries, who keep a number of the largest kind of tiger in menageries, often make them

their executioners, by throwing to them persons doomed to death, who are of course quickly despatched and devoured.

There are two species of lion, one without a mane, found in India, and another resembling the African lion, but with a smaller mane, and less powerful, found from Syria eastward. Leopards, panthers, and ounces, are common: the jackal, a canine animal, is found in Syria and the adjacent countries, where it goes in packs. This is the fox of the Bible. The hyena is common almost everywhere, and wild dogs abound in the mountains.

Asia is most prolific in quadrumans, nearly two hundred species being peculiar to it. Many are found in India, and more occur among the islands. The most remarkable is the orang-outang, (wild man,) or red orang, which most resembles the human figure of all the lower animals, except the black orang of Africa. It is found only in Borneo and Sumatra; it is about 5 feet high, and possesses great muscular power in its arms.

The mammals of Australasia are mostly marsupials, there being upwards of 100 species: there are no quadrumans, ruminants, or pachyderms. The largest of the marsupials is the kangaroo, which is easily domesticated, and of which there are eight species. Some of them are carnivorous and fierce, such as the animal called the tiger hyena; but it does not belong to the carnivoran order. The principal animal of this order is the dingo, a kind or dog, which is found both wild and domesticated.

Polynesia offers little that is interesting under this head: the principal mammals found there were dogs and hogs, which appear to have been introduced along with the natives, from Malaysia, although several of the common domestic kind have been introduced of late.

§ XXIV.—Mammals of Africa.

The mammals of Africa are very interesting, and upwards of 250 species are peculiar to it; but many of them so much resemble those already considered that we need not mention them. Of its ruminants, the most abundant are the antelopes, of which there are upwards of fifty species, none of which, we believe, have ever been domesticated. They go in immense herds, with sentinels, which give an alarm in case of danger. They are extremely swift, and are caught by the carnivorans chiefly by being surprised when they come to drink at the streams and springs. The deer species are few in number,* and confined to the Atlas Mountains. The camelopard,

* The deer tribes are distinguished from the antelopes by having the horns solid and *deciduous, or shed* yearly, whereas those of the latter are hollow and

[illegible] singular of all ruminants. It is [illegible] of its neck, which makes [illegible] any other terrestrial animal, and [illegible] which causes its back to [illegible] place is between the [illegible] a mane and tufted tail like a [illegible] gnu of southern Africa, [illegible] horse," is an antelope, [illegible] the giraffe—two in number [illegible]—are small, and covered [illegible] powerful, owing to the long [illegible] having been known to drive [illegible]. Its prominent eyes enable it [illegible] that it can guard against stealthy attacks [illegible]. It has very strong and powerful hoofs, which [illegible] when attacked, as frequently to [illegible] the lion. But it is a very harmless animal, and [illegible] of necessity. It inhabits all Africa south of the Sahara, and like its allied species, is gregarious.

The zebra and the quagga, animals of the horse kind, are peculiar to southern Africa; and in the same region, as well as in central Africa, is found the only other extant species of elephant besides the Asiatic, from which it is distinguished by its huge ears, its convex forehead, and having three nails on the hind foot instead of four. It is also smaller in size, with shorter tusks. Of the rhinoceros, there are four or five peculiar species, all found in central Africa, some with two, and some with one horn. The hippopotamus is found along all the great rivers, from the Nile to the Orange. This animal is exclusively African; and there is only one species. It generally passes the day in the rivers, with its nostrils above water, and comes out at night to feed on the banks. It is an herbivorous and harmless animal.

The carnivorans of Africa are numerous and formidable. The African lion, which is found all over the country, is the most powerful of all the carnivorans, and the most formidable of all animals. The largest variety is found in northern Africa. Many stories are told in books regarding the lion's generosity; but those who have lived near him, give them no credit. His attack is as stealthy as that of the tiger; and many fatal rencounters prove that the supposed power of the human eye to awe the lion, must be classed with fables. In boldness, however, as well as strength, he exceeds the tiger; and he is also less addicted to wanton cruelty, and more easily tamed. Indeed there is no doubt that he is quite as susceptible of

permanent, as in the ox. Deer are also distinguished from all other ruminants by having no gall-bladder.

stication as the cat,* which he closely resembles in structure; iis enormous strength and voracity would render him a very rous and unprofitable companion. Leopards and panthers id throughout Africa; and foxes swarm in every part of the ry. There are also several species of wild dog, of jackals, and is. The latter generally hunt in packs, and by this means often ome opponents of the cat tribe, the lion not excepted; for all are solitary animals, while the canine tribes—such as the dog, fox, jackal, and hyena—are gregarious, and generally go in

the weasel tribe, the most remarkable is the ichneumon, wored by the ancient Egyptians. It is domesticated both in Egypt i India, where it is much more efficient than the cat in destroyits, mice, snakes, lizards, and other vermin. It is particularly for devouring the eggs of the crocodile; and its services probaded in freeing most of Egypt from that formidable reptile, is now seldom seen even in Upper, and never in Lower Egypt. ancient story of its leaping into the crocodile's mouth when , and devouring its intestines, appears to be a fable. It is easily sticated, and becomes attached to the house and its master. adrumans of many species abound in all the warm regions of , beyond the Sahara, and a few are found in Barbary. There irious kinds of baboons, and two or three species of the chime, or African orang, which is as large as the Asiatic orang, and formidable. This animal bears a closer external resemblance to han any other.

§ XXV.—Marine Mammals.

the *phocidæ*, or seal tribe of carnivorans, there are many s, of very various sizes and appearance. They are all covrith a layer of fat, like the cetaceans, and yield a valuable oil, their skins are applied to a great many uses. They are found ind the shores of the polar seas, and down to about the 50th el, but seldom lower. The Greenland seal is to the Esquimaux, the reindeer is to the Laplander,—his principal means of subve. The walrus, or morse, is among the largest of the tribe, about 20 feet in length, with two tusks two feet long, turned perpendicularly down. It is found only in the arctic seas. ommon seal is found on the north-western coasts of Europe, round Greenland. It is about 6 feet long, with a head very

he wild-cat is fiercer than the lion, and exhibits more of the peculiarithe tiger, as well as a greater external resemblance, being marked with tripes, very similar to those of his more powerful congener.

like a bull-dog's. The otarians, or sea-lions, are found chiefly in the southern hemisphere. They are characterized by having projecting external ears, which the other kinds want. They are mostly larger than the common seal.

The cetaceans, or whale tribe, consist of three genera.

1st. *Herbivorous cetaceans*, with flat grinding teeth, and no incisors or canines in the adult. The principal kinds are the manatee, lamantin, or sea-cow, and the dugong, or mermaid. The former are found chiefly in the Atlantic, round the mouths of the large rivers, and the latter in the Indian Ocean and the adjacent seas. The manatee is about 14 feet long, and lives on the rank vegetation at the bottom of streams. The dugong is seen chiefly in salt water, and feeds on marine plants. It sits upright when suckling its young; and this gave rise to the fabulous stories told of it, under the name of the mermaid, or sea-maiden. The whole tribe are gentle and harmless animals.

2d. *Rapacious cetaceans*, with sharp teeth, and long jaws. These are carnivorous, living on fish, and very fierce. They are found in every sea, from pole to pole. The largest kind is the well-known sperm-whale, which is 75 feet long, when full grown, and 50 feet in circumference. They are found in every ocean except the Arctic, but are at present most numerous in the North Pacific and the Antarctic Ocean. The spermaceti is found chiefly in an immense cavity in its head. This animal defends itself desperately when attacked; and the fishery is attended with great danger. It is carried on mostly by American ships from New England. The smallest of this tribe is the porpoise, always seen in shoals, and often following fish up into rivers, where they are frequently left by the tide, and taken. The dolphin* is larger than the porpoise, being about 18 feet long; and the grampus is still larger, and much fiercer. The male of the narwhal, or sea-unicorn, has an immense tusk projecting from the forepart of the head, to the length of about 9 or 10 feet. This is as hard as ivory, and wreathed throughout its length with a spiral groove. There is a second rudimentary tooth in the jaw, and these are all the animal possesses. In the female, both teeth are in a rudimentary state. The narwhal is generally about 15 feet long, exclusive of the tusk, and is found chiefly in the Arctic Ocean. The porpoise and grampus are found through the Atlantic and Antarctic Oceans also.

3d. The *balænæ*, or whalebone whales, which have no cutting teeth, and no fin on the back, and have whalebone in the upper jaw. This terminates in a fringe of coarse strong hairs, which are in contact with the upper surface of the tongue, when the mouth is

* The coryphene, which assumes a succession of brilliant colors when dying, is termed dolphin by the poets; but it is a true fish, and entirely different.

closed. The water which the animal gulps in huge mouthfuls is drained off through the interstices of the whalebone plates, and the small molluscous and crustaceous animals contained in it are sifted out, retained, bruised between the tongue and hairs, and finally swallowed. The gullet of the largest of these whales is only a few inches in diameter, while that of the sperm-whale is large enough to swallow a man whole. The Greenland whale, called by seamen the *right* whale, is the most valuable of all the cetaceans, because it yields a great quantity of oil, and its whalebone is of great value. It is also less fierce than many other species. This has led to its being nearly exterminated. It is now found only in the remotest parts of the Arctic Ocean, and even there only in small numbers. The rorquals differ from the right whale in having longer heads and less whalebone; whence they are often termed the *small whalebone* whales. From this term some suppose that they are smaller than the right whale. This is not uniformly the case: the right whale is never more than 75 feet in length, while the *balænoptera*, a species of rorqual, is often found 120 feet long, being the largest of all known animals, living or extinct. It is much fiercer, however, than the Greenland whale, and yields much less blubber as well as whalebone. Hence it is much less sought after. The rorquals are found in the Pacific and more abundantly in the Atlantic Ocean.

DIVISION SEVENTH.

ANTHROPOLOGY, OR ACCOUNT OF HUMAN RELATIONS AND INSTITUTIONS.

PART I.

ETHNOLOGY, OR ACCOUNT OF THE VARIOUS RACES AND CLASSES OF MANKIND.

---

§ I.—Divisions, Extent, and Population of the World.

Ortelius and Mercator, in the sixteenth century, conceived the idea of dividing all known lands into three grand portions: viz. the Old World, comprising Europe, Asia, and Africa; the New World, or North and South America; and Terra Australis, Magellanica, or Austral, or Southern World: to which Varenius added the Arctic World. At a later period, when the knowledge of the Pacific became more extensive, but the notion of a southern or antarctic continent still prevailed, De Brosses proposed the name of Australia for the islands of New Holland and the surrounding groups; Polynesia, for the groups scattered over the Pacific; and Magellanica, for the supposed southern or antarctic continent. Finally, geographers have agreed to consider the island world of the Pacific Ocean a separate division, called by the name *Oceanica.* Adopting this classification, we may divide the land of the globe into three great divisions, called worlds, which are completely separated from each other by the ocean: 1st. Old World, subdivided into Europe, Asia, and Africa; 2d. New World, subdivided into North America and South America; 3d. Maritime World, subdivided into Malaysia, Australasia, and Polynesia.

The whole land area and population of the globe have been differently estimated, as in reality neither is accurately known, and will not in all probability be so, for ages to come. We subjoin three of the most authoritative estimates, from Hassel, Balbi, and the

Weimar Almanac for 1840, omitting the smaller numbers, which cannot be depended upon, in any such case. The statistics from the Almanac are the most recent to which we have access; they appear to have been compiled with care, and are probably nearest the truth, though, in some cases, no doubt, incorrect.

I. AREAS IN SQUARE MILES.

	Hassel.	Balbi.	Weimar Almanac.
Europe, ...	3,000,000	3,211,000	3,807,000
Asia, ...	16,000,000	13,935,000	17,805,000
Africa, ...	11,000,000	9,775,000	11,647,000
America, ...	15,500,000	12,817,000	13,542,000
Oceanica, . . .	3,400,000	3,565,000	3,347,000
Total,	48,900,000	43,303,000	50,148,000

II. POPULATION.

	Hassel.	Balbi.	Weimar Almanac.
Europe, ...	227,000,000	227,700,000	233,240,000
Asia, ...	470,000,000	390,000,000	608,516,000
Africa, ...	110,000,000	60,000,000	101,498,000
America, . . .	43,000,000	39,000,000	48,007,000
Oceanica, . . .	2,600,000	20,300,000	1,838,000
Total,	852,600,000	737,000,000	993,099,000

§ II.—Varieties of Mankind.

The careful and extensive researches of Dr. Prichard,* have proved to the satisfaction of all physiologists of any note, that there is only one species in the order *bimana*, and that all the differences we observe in the physical character of nations, have resulted from the different circumstances that operated upon them, just as we see varieties incessantly appearing in the same species of plants and animals, sometimes much more unlike than the most dissimilar of the human family. As this subject is neither uninteresting nor unimportant, we shall give a brief statement of the conclusions established, referring for full details to the works mentioned in the note below.

* These are given in his *Researches into the Physical History of Mankind*, (London, 1839–1844, 4 vols. 8vo., 3d ed.), *Eastern Origin of the Celtic Nations*, (Lond., 1831, 8vo.), and his *Natural History of Man*, (Lond., 1845, 8vo., 2d ed.) The last work comprises the substance of the first, with additional illustrations.

The peculiarities chiefly relied upon by those who have maintained that man is of several species, are, the color of the skin, the nature of the hair, and the peculiar conformation of the bones, particularly of the skull. It is sometimes stated in popular works that there are differences in the *structure* of the skin; but every anatomist knows that such is not the case. With respect to the color of the skin, it exists only in the cuticle or scarf skin, which is immediately above the *cutis vera*, or true skin; and it depends on the presence of a number of pigment cells, which are intermixed with the ordinary cuticular cells. On taking an extensive survey of the human race, we find these cells exhibit every intermediate hue, from a very light brown to jet black. The matter is never absolutely colorless, or of any other hue than some kind of brown or black. In some varieties, however, it is not uniformly distributed in every individual, but in patches, constituting what are termed freckles. These occur only in fair-skinned varieties. The various shades of color also pass insensibly into each other; and they are generally connected with climate. There is here wanting, therefore, those sharp and sudden transitions which distinguish species. If the negro be of one species, and the Dane of another, to which belongs the brown Italian, or Spaniard? If you say to the white race, we ask, to which belongs the still darker Arab?—and the still darker Nubian? But the argument founded on color is directly met and contradicted, by the historic fact that the very same race exhibit every shade of color. We may instance the great *Indo-Atlantic* family, (otherwise called *Indo-European*, *Indo-Germanic*, or *Japhetic*,) which stretches from India across the whole breadth of the old continent to Ireland, and now, from the Atlantic across the whole breadth of the New World to the Pacific. This family is so connected by language, and by mental and physical peculiarities, that no physiologist whatever disputes their being of one race. Now among them we find every shade of color, from the black of the Southern Hindoo* to the fair and florid hue of the Hollander, or the Briton. The rapidity with which color changes is seen in the English colonies of North America. It is not 250 years since the very first colonists arrived from Britain, and a much shorter time since the ancestors of most of the present New Englanders crossed the ocean, and yet they have lost the clear complexion of their kindred beyond the water, and acquired much of the hue of the southern French, or northern Spaniards, so that, if an assemblage of each nation were placed side by side, there could be no difficulty whatever in distinguishing them by their complexion alone. With respect to intermixture with the Indians, we know as a matter of fact that it never took place. The aborigines of America

* The Hindoos alone, indeed, present every shade, in the color of the skin, eyes and hair; some being black, others dark, and others fair.

are another instance. They are all unquestionably of one race; and yet as we move from around the lakes southward, they become darker and darker, till in the plains of the Orinoco and the Amazon they are nearly black, while on the cool and humid shores of the Pacific they are found fairer than many Europeans, and their cheeks frequently display the ruddy hue common among white men. On the elevated mountain and table lands of South America, the hue is much lighter than in the plains. We are well aware that it has been repeatedly stated the American Indians are all of one hue. Such assertions could have proceeded only from theorists, who had either a very limited, or no acquaintance with them. The Arab tribes, also, exhibit a great variety of hues, from the black of the Mogrebba of the Sahara, and the dark brown of the Shegya, or the native of Oman, to the comparatively fair hue of the Arab of Lebanon. The answer to such facts is—intermixture. But the other features often show that there has been no intermixture. Thus, the Mogrebba Arab shows by his features, hair, and general expression, that he is not blackened by being partly of negro descent. There is another fact which proves that the answer of intermixture is unsatisfactory. Where change of complexion is produced, as it often is, by intermixture, there is only an approximation to either of the colors: thus, the mulatto is never as black as the negro. Now in the cases we have mentioned, there is a complete similarity of hue. The argument from intermixture is further rebutted by historic knowledge. Thus, the Jews are a people who have ever, according to the prophecy, "dwelt alone," without intermixing with "the nations" to this day. Now this separate race, all descended from brown ancestors, (for Abraham, Isaac, and Jacob must have been as dark as Mar Yohannan,* if not darker,) exhibit every shade of color, from the black Jews of Malabar, of whom we have such an interesting account by Dr. Claudius Buchanan, to the rose and lily complexion of the Jewesses on the banks of the Elbe. We need go no further than the Jews of southern Spain, and compare them with those of Holland and northern Germany, to perceive a very striking difference. The Spanish Jew is always dark-complexioned, and his hair is uniformly black, whilst the German Jew is often as fair as any German, and has light or red hair, with blue eyes. The various shades of color observable among the negro, or African race, tends to the same conclusion. Along the coast of Guinea, which is low, marshy, and hot, we find jet-black complexions, and this is the very country from which American negroes have been derived; but when we come to

* The celebrated Nestorian bishop, who was in this country in 1842. Though a native of northern Persia, he is quite as dark as a mulatto, while there is not even a remote possibility of his having had Hindoo or negro ancestors.

the elevated regions of the interior, or pass into southern Africa, we find the very same race of various shades of brown, from a dark mahogany to a light copper, like that of the Foulahs of the Kong Mountains. The Creator does not produce great changes in organic beings by sudden starts and bounds, but wisely introduces them by gradual alterations. Hence when races change their localities, the color—as well as other characteristics—changes only by degrees. But in the course of ages, it always conforms to the climate; and hence, without a single exception, we find all races long settled in low, marshy, and hot regions, very dark, or black, and those long resident in cool and equable climates, fair-complexioned; while in regions of an intermediate character we find an intermediate color. The Africans of the Northern States are already several shades lighter than their Guinea ancestors, even in those cases where their thoroughly negro hair and features show that they are not of mixed descent.*

With respect to the peculiarities of the hair, some of these change more slowly than the color of the skin. So far, however, as its color is concerned, that is of less value than what we have been considering, since it is very common to see brothers german with hair of the most unlike hues. But the *texture* of the hair has been supposed to exhibit a permanent distinction. This, however, differs from the other only in degree: for, the Negro, or (to use a common, and more proper expression,) the African race, exhibit every variety of structure, from the most crisp to curling and flowing locks. Microscopic examination has shown, that the most crisp human hair does not differ a whit in structure, from the most straight,—the matting property of wool, (arising from small notches in the hairs,) being equally absent in both. The term *woolly*, indeed, must have been applied to the African's hair, by persons who were acquainted only with the wool of one kind of sheep: for, in the ovine race, the wool is oftener straight than crisp.

With respect not only to the skeleton, but to the whole anatomical structure of man,—teeth, bones, bloodvessels, muscles, nerves, &c.,—there is no more difference between the various races of mankind, than is frequently met with in different individuals of the same race, nor indeed near so much. Thus, to take an example that may be generally known: there have been many cases since the days of the Gathite, mentioned in the Old Testament,† where persons were born with six fingers on each hand, and six toes on each foot, although it

* We would ask those who make color a distinction of species, whether the large brown patches often met with on the skin makes such parts of a different species from the rest; and whether the black side of a cow or cat is of a different species from the white?

† See 2 Samuel xxi. 20.

is well known, that there is no such difference between the most dissimilar races of mankind. The form of the skull, to which much importance has sometimes been attached, is as variable as the complexion. Of this the Turks and Magyars are striking examples. Both belong to the Mongol race; and in the course of time, they have completely lost the pyramidal form of the skull, peculiar to that race. It may be said that the Turks intermixed with other races; but this is not true. Any affinity with the "unbelieving dogs," (as they term all who are not Mohammedans,) they abhorred; and to refer to the Circassians does not avail: for they also are of the Mongol race, as their language shows. Moreover it was only a few of the wealthier Turks that ever intermarried even with the Circassians: for, the great mass of them intermarried among themselves exclusively, from before the days of Orcan Ben Ogloo, to the present time. Their brother Toorkmans, in Tartary, have still the Mongol peculiarities.

Among the African race, again, we find great diversities in the form of the skull. That of the Guinea Negro is well known: the Mandingoes of Western, the Gubers of Central, and the Kaffirs of Southern Africa, present forms differing little, and sometimes nothing from that of Europeans.

The human race is, therefore, specifically one: there is no permanent or specific difference between one race and another. And as one variety often passes, by slow gradations, into another, a scientific and accurate classification of them is impossible, from the nature of the case. That of Blumenbach has been, for some time, more generally received than any other; and therefore, we give an outline of it. He divides the human race into five varieties.

The first is now called the *Iranian*, (from Iran, ancient Persia,) and occupies western, and part of southern Asia, eastern and northern Africa, Hindostan, and Europe, besides the white population of America. This race is sometimes called the Caucasian, from the belief of its having originated near the Mountains of Caucasus, in Asia,—although that is a groundless opinion. The principal nations comprised under this head, or class, are the Europeans, and their American descendants, the Arabs, Moors, Turks, Persians, Hindoos, and Abyssinians. They are distinguished by the following peculiarities, viz., long hair, generally waving or curling, black, red, flaxen, or brown;—the head round, the face oval, straight, and narrow; the forehead smooth; the nose high, and generally more or less arched, with a slight depression only at the root; the mouth small, and the teeth set perpendicularly.

The second variety, comprised under this head, is the *Tartar*, *Mongol*, or *Turanian* race, and includes all the nations of Asia east of the Caspian Sea and the Ganges, except Malacca. It embraces, also, the Laplanders, and Finlanders, in Europe, the aboriginal Sibe-

rians, and the Esquimaux, from Bhering's Straits to Greenland. The characteristics of this race, are, a yellow, tawny skin, black, straight hair, head square, eyes set obliquely, face large and flat, nose small and flat, cheeks round and prominent laterally, and the chin pointed. This is also called the Eastern variety.

The third race, or *American* variety, consists of the aborigines of America, (exclusive of the Esquimaux,) by some writers believed to have sprung from a horde of wandering Tartars, who crossed over to the peninsula of Alashka.* Their distinguishing characteristics are a copper-colored skin—sometimes of a very light, and sometimes of a nearly black hue; black, straight hair; low forehead; eyes deep set, or sunk; cheek-bones very prominent, and face large. There is a strong similarity to be observed between the Tartar, or Mongol, and the American races.

The fourth race is the *Malay*, or *Malayo-Polynesian*, comprehending the inhabitants of Malacca, Malaysia, most of Polynesia, and part of Australasia. The following are its distinguishing features: a tawny complexion, hair black, soft, profuse, and curled; the forehead very prominent; the nose thick, small, and bulging; and the upper jaw slightly projecting.†

The fifth race is that of the *African*, or *negro*, which is spread over the whole of western, central, and southern Africa. It is also found in Madagascar, intermixed with the Malays, and in some of the islands adjacent to Asia, and occupies New Holland, Van Diemen's Land, New Caledonia, New Guinea, and part of New Zealand. The distinguishing types of this race, are, dark hue; black, curly hair; head narrow, and compressed at the sides; the forehead convexed and arched; cheek-bones projecting forward; nose thick and flat; lips thick and protuberant; chin drawn in; upper jaw projecting, and teeth set obliquely; feet flat and broad; and legs crooked.

The preceding division has been rendered more exact by Dr. Prichard, who distinguishes four varieties in Blumenbach's negro, viz.: the African—just described—the *Hottentot*, the *Papuan*, or *Australasian*, and the *Alfourou*, or *Alforian* race. The Hottentots are

* It is more probable they are descended from Japanese, who sailed along the Kuriles to Kamschatka, and thence along Bhering's Isles and the Aleutians to Alashka; for the Tartars were not a seafaring people. But whether sprung from Tartars, Japanese, or Chinese, there can be little doubt they are descended from the Mongol tribes of eastern Asia.

† Such statements must be understood as being only generally true; for some individuals of the Malay race—the Tahitians for example—have Roman features, with brown, red, or flaxen hair. Such were found amongst them when first discovered, so that the ready reply of "mixed blood" will not avail. A similar remark applies to all the races. Not only individuals, but sometimes whole tribes, diverge widely from the characteristics which Blumenbach attributes to them.

distinguished by a tawny buff, or fawn color; very wide and high cheek bones; a flat nose; oblique eyes; and hair scanty and growing in tufts. The Papuans, (who occupy most of the islands of Australasia, the Andaman Isles, and the interior and mountainous parts of Borneo, and some of the other Malaysian islands,) are of small stature, seldom exceeding five feet; the complexion is sooty, rather than black; the hair grows in tufts, with a spiral twist; the forehead is higher, the nose more prominent, and the upper lip longer, than in the African; the under lip is protruded; and there is scarcely a vestige of a chin. The Alfourous are few in number, being found chiefly in the interior and southern portion of New Guinea, and the central parts of the Moluccas and Philippines. Their complexion is very dark; their hair is thick, straight, and uniform all over the head; the nose is so flat as to give the nostrils an almost transverse position; the eyes are large, and the legs long and slender. These are considered the earliest inhabitants of Malaysia and Australasia; and it is supposed that they were supplanted first by the Papuans, and afterwards by the Malays, who seem to have succeeded the latter at a much more recent period.

Blumenbach's division is objectionable in classing together the *Aramaic*, or *Syro-Arabic* race, (including the Arabic race, Jews, Nestorians, and Syrians,) and the *Indo-Atlantic* race. These two races are distinguished both by the difference in their languages, and by several peculiar physical and mental traits. Recent researches also show that the Copts, and the Nubians, belong to the African race. This is proved by their languages and physical peculiarities,* the former of which are very peculiar. They show the full countenance, almond-shaped eyes, wide nostrils, thick prominent lips, small chin, and bushy hair, generally common among the Africans. The very same peculiarities marked the ancient Egyptians—the ancestors of the Copts.

Of Blumenbach's five races, the Caucasian ranks first, and is superior to the others in intelligence, courage, invention, enterprise, and high moral attainments.

Such are the principal varieties of the human species spread over the face of the globe. Navigators have found inhabitants in the most sultry climates, and in the neighborhood of the Poles, upon the most inaccessible coasts, and even on islands that a wide ocean seemed to separate from the rest of the world. The islands of Spitzbergen, and Nova Zembla to the north, the Galapagos, Juan Fernandez,

* It has been inferred from the form of the ancient Egyptian skulls, that they belonged to what is vaguely termed the Caucasian race; but similar forms are common among the Kaffirs, Foulahs, &c. When we are told the ancient Egyptians built the Pyramids, we ask, did Caucasians build the equally stupendous edifices of Central America?

Sandwich Islands, the Falkland Isles, and a few others, are the only countries of considerable extent which have been found entirely destitute of inhabitants, if we except the newly discovered lands in the antarctic regions. Man's habitations reach to the remotest confines of animated nature. He can inhabit every climate; the Esquimaux, of Greenland, live as far north as the 80°. In the southern hemisphere, the bleak and barren Terra del Fuego, supports the Petcheres; so that the New World is inhabited from one extremity to the other. In the Old World, the habitations of man form a collected whole, which is broken in upon merely by wide deserts; and in the midst even of these, man has peopled the oases or verdant islands scattered over an ocean of sand. The human body sometimes supports, upon the banks of the Senegal, a degree of heat which causes spirits of wine to boil. In the north of Asia and America, it frequently resists cold which freezes mercury. As the intensity of the cold does not increase beyond the 80° of latitude, it is probable that navigators could easily sail directly over the Pole, were it not for the ice that constantly surrounds it.

§ III.—Ethnographic Table.

The following table exhibits the numbers of the different races of men, according to Hassel's enumeration:

I. IRANIAN, OR CAUCASIAN RACE.

Circassians and Georgians, ...	1,118,000
Arabians, Moors, Jews, Abyssinians, Berbers, and Armenians, ...	54,523,000
Hindoos, Persians, Curds, Afghans, and Belooches,	143,353,000
Greeks, ...	4,834,000
Arnauts, ...	530,000
Sclavonian Nations; (Russian, Poles, Bohemians, Lithuanians, Croats, &c.,)	68,255,000
Germans, Dutch, English, Swedes, Danes, and Norwegians, ...	60,604,000
Roman or Latin Nations; (French, Italians, Spanish, Portuguese, Walloons, and Wallachians,) .	75,255,000
Low Bretons, Welsh, Caledonians, Irish, and Basques, ...	10,484,000
Total,	419,530,000

II. MONGOLIAN, OR TURANIAN RACE.

gol Nations; (Toorkmans, Turks, Usbecks, irguis, Thibetans, &c.)	52,937,000
iese, ...	256,200,000
nans, Siamese, and Anamese, ...	33,850,000
inese and Mantchoos, ...	60,420,000
, Esthonians, and Laplanders, ...	2,878,000
iimaux, Siberians, and Kamschatdales, . .	185,700
Total,	406,470,700

III. MALAY RACE.

ys, inhabiting the Peninsula of Malacca, Maysia, and Polynesia, ...	38,800,000

IV. ETHIOPIAN, OR NEGRO RACE.

can Negroes, ...	62,983,000
res, ...	5,200,000
tentots, ...	500,000
nans, or Oriental Negroes, (Australians, Panans, &c.,)	950,000
Total,	69,633,300

V. AMERICAN RACE.

th American Indians, ...	5,130,000
th American Indians, ...	5,140,000
ibees, ...	17,000
Total,	10,287,000

VI. TOTAL OF EACH RACE.

casians, ...	419,530,000
golians, ...	406,470,700
ays, ...	32,500,000
opian, or Negro Race, ...	69,633,300
erican, or Copper Colored, ...	10,287,000
Total of the globe,	938,421,000

§ IV.—Causes of the Variations in the Human Race.

Several commentators on the Holy Scriptures, consider the varieties of mankind to have sprung from the peculiar character and circumstances of Noah's three sons, Shem, Ham, and Japhet. These certainly peopled the whole earth; and it has been supposed that miraculous interference was necessary to produce the varieties in the human race that now exist. This hypothesis is inadmissible for two reasons:—1st, there is not the shadow of any historical proof of any such miracle, and 2d, it is not necessary to have recourse to miraculous agency to account for those variations. The supposition was indeed formed in ignorance of several of the facts which we have stated in Sect. 2. We can trace the gradual formation of those varieties by known causes, such as difference of climate, food, clothing, pursuits, modes of thinking, &c. But before proceeding to consider these, we shall briefly notice the particular arguments of those who maintain that there was miraculous interference on the part of the Most High.

It has been asserted, that the African race are descendants from Ham, and that therefore they are accursed, and "the servants of servants,"—that the Mongol race are descended from Japhet, who has been "enlarged" by spreading over central and eastern Asia, and has "dwelt in the tents of Shem," upon the conquests of the Turks, Gengis Khan and Timur. The Caucasian race are thought to be the descendants of Shem. This view is supposed to agree with facts and Holy Writ; and Cuvier's opinion is quoted, according to which there are only three varieties of men, the Caucasian, or white, the Mongol, or brown, and the African, or black. We have already seen, that this view does not accord with facts. Instead of three, we have six or seven varieties; and, instead of the complexions of the different varieties being constant, we find them of various hues. It is also easy to show, that the prophecy of Noah (Genesis, ix. 25–27,) and the narrative of Moses, are equally at irreconcilable variance with any such view. Noah cursed *Canaan*—not *Ham*—and declared Canaan should be Shem's servant. Now, the very next chapter will unfold the exact fulfilment of the prophecy. There we are told, that Canaan's descendants were Sidon and Heth,* the Jebusites, the Amorites, the Girgasites, the Hivites, &c. Then we are ex-

* We may state that, according to the uniform testimony of all Biblical scholars, Heth was the ancestor of the Hitites, so frequently mentioned afterwards as a nation of Canaan; the difference between *Heth* and *Hit* depending on the vowel points, an invention of a date more than 2000 years posterior to the death of Moses. Instead of Hitites, Dr. Boothroyd always writes

pressly told the boundaries of the territories occupied by Canaan's descendants. They extended from Sidon to Gaza, (two well-known towns in Palestine,) on the sea-coast, and then "unto Sodom and Gomorrah, and Admah and Zeboim, even unto Lasha." Now, as Sodom, Gomorrah, &c., occupied the present site of the Dead Sea, it is evident that the territories of Canaan's descendants were comprised within the land of Canaan, so often mentioned, and so called, from the very fact of its being settled by the Canaanites. We arrive at the very same conclusion, if we examine the particular locality of the various tribes mentioned, most of whom are very frequently spoken of throughout the Old Testament. The prophecy, that Canaan should be Shem's servant, was fulfilled when the Israelites conquered their country, under Joshua, and made such as were spared "hewers of wood, and drawers of water." Such as remained in any degree independent were thoroughly vanquished by David. The Canaanites became literally, "servants of servants," when the Hebrews were successively under the yoke of the Assyrians, Babylonians, Persians, Greeks, and Romans.

With respect to Ham's other descendants, we are told, that among them was Nimrod, who, instead of being a "servant," was the founder of a great and independent monarchy, and the builder of Nineveh,* that "exceeding great city, of three days' journey."† Among Ham's other descendants, we find Mizraim, the Egyptians, as all Hebrew scholars tell us,‡—this being the only term for that people throughout the Old Testament. Now, the Egyptians were among the first, if not the very first, of civilized nations, and their country has been justly termed "the mother of arts and sciences;" and, instead of being servants, they were, for a long series of ages, the most powerful, as well as the most intelligent people in the world; and at one time they subdued a great part of Asia and Africa. True, their greatness passed away: but what ancient greatness has not? The more we learn of them, the more we are astonished at the surprising progress they had made in knowledge, and the variety and vastness of the fruits of their arts and power, at a time when all Europe presented a very different spectacle. The Egyptians were not black, as we know from innumerable proofs, but of a reddish, or yellowish brown.

From the account given of the numerous descendants of the Egyptians, (probably colonies, settled in all the more eligible parts of Africa, at a very early period,) and from the close resemblance between the Coptic, or Egyptian, and the languages of Soudan and southern Africa, we think there is little room to doubt the correct-

* See marginal reading of v. 11, which critics tell us is the true rendering: see Micah v. 6.

† Jonah iii. 3.

‡ See Genesis l. 11, and marginal explanation.

ness of the current opinion, that the other Africans are descendants of Ham. But it must not be forgotten, that there is no prophecy whatever, about the destiny of Ham's existing descendants,—the ancient Egyptians being virtually extinct, and that the many populous and powerful states, discovered in Africa within the last 20 years,—containing large cities, and inhabited by an agricultural people,—prove, that the most numerous of Ham's descendants are not servants:* and from the terrible results of the late great expedition from England to central Africa, and several other occurrences, which all lead to the same conclusion, there is not the least probability that the great body of the Hamites will ever bow their necks in future to the descendants of either Shem or Japhet; and they never did in times past. The Almighty seems to have assigned to the Africans, as their heritage, the greater portion of the extensive continent on which they dwell.

Let us briefly see what is Japhet's portion. After mentioning the sons of Gomer and Javan, two of Japhet's sons, Moses adds: "By these were the isles of the Gentiles divided in their lands." Now, the table-lands and deserts of central Asia could not, by any possibility be termed *islands*. Hence, the Mongols cannot be the sole descendants of Japhet. The "isles of the Gentiles" must have meant the isles of the Mediterranean, as no others were known to those whom Moses addressed; and the term probably includes all of Europe then known to the Israelites.

As we find in this country the Indo-Atlantic race, the conclusion is inevitable, that, according to an old and current opinion, they are descended from Japhet. From Europe they have overspread America; and from western they occupied a great part of central and southern Asia; and their colonies seem destined to occupy most of Oceanica. Thus, the descendants of Japhet possess most of Europe, and Asia, and the greater part of the New World. Hence, the prophecy has been amply fulfilled. The ancient Iberians, the ancestors of the present Basques, were most likely of Hamite descent; and this is the preponderating element in the Spanish and Portuguese races, and in part of the French.

The little that is said by Moses of the location of Shem's descendants, leads us to infer that they settled in the East, around and beyond the Euphrates. There is not a trace of them in Europe, till Judea became subject to the Romans, a little before the Christian era. From them are probably descended the Afghans, the Tartars, Chinese, and

* With respect to those sold into foreign slavery, they formed but an insignificant fraction of the whole,—not so many as the number of white slaves at Constantinople, or in the former markets of Algiers, Morocco, &c., to say nothing of the innumerable white slaves of the ancients, and indeed of the moderns.

Malay races, the American Indians, and the first inhabitants of India and Oceanica.

The fact with respect to Noah's three sons, appears, therefore, to be, that several varieties sprung from one, and the descendants of all three are sometimes placed in the same subdivision, as in the case of the Jews and Arabs, descended from Shem, the Greeks descended from Japhet, and the Phenicians and Carthaginians descended from Ham. We must, therefore, look elsewhere for the cause of these varieties in the human species, which forms the main subject of inquiry.

The prophecy regarding Shem is clear, and the fulfilment obvious. God was to enlarge Japhet: but He (i. e., God,) was to dwell in the tents of Shem; and He did dwell in the tents of Shem, from the day when He appeared to Abraham at Mamre, till Jesus ascended from Olivet, a period of about 2,000 years. It was among them He appeared in the tabernacle, in the temple, and on special occasions. To the race of Shem alone, all real revelations were made; those heard of among the descendants of Ham or Japhet, being all impostures or delusions. Of Shem's descendants were the patriarchs, Moses, and all the prophets and apostles; and among them appeared the Teacher, who was greater than either Moses or the prophets. To apply this prophecy to Japhet's dwelling in the tents of Shem, is allowed, indeed, by the grammatical construction, but not by the sense, which it renders vague and unmeaning. The other construction is, as Archbishop Secker long ago observed, both the most natural and the most suitable.

An equable climate is favorable to great stature; and hence the natives of the southern hemisphere are taller than those of the northern—such as the Patagonians, the Boors and Kaffirs of southern Africa, and the New Zealanders. This tendency is said to exhibit itself in the very first descendants of the British settlers in Australia. They are taller and more slender; hence they are termed, in slang phrase, "currency," while the immigrants are distinguished as "sterling."

The difference among mankind in point of stature appears to be owing to the various modes of life, various kinds of food, and difference of climate. Salubrious climates, for example, active and temperate habits, and nutritious food, give organic beings large, hardy, and graceful forms. But symmetry of form often depends upon the peculiar local character of the climate, and upon artificial causes. Thus the custom which prevails among some of the Negroes, the Caribbee and Flathead Indians, the inhabitants of the Society Islands, &c., of depressing and flattening the heads of new-born children, alters the configuration of the skull, and produces a frightful deformity. The Magyar descendants of the ancient Huns, (who were so

hideous that they were said to be sprung from the devil,) are now a fine, handsome race; and the offspring of the ancient Gaul, or German, (so terrible to the Romans for their huge stature and fierce aspect,) can hardly be recognized in the four-feet-eleven peasant of a French commune, or the deformed and stunted operative in an English factory; and among the myriads of German immigrants in this country, a tall person is only a rare exception.

Variety of color depends chiefly upon external circumstances. Thus, besides the instances formerly mentioned, we often observe, in the same nation, individuals of extremely different complexions. While the Moorish ladies shut up in their houses, and scarcely ever exposed to the sun, have fair complexions, the women of the lower ranks, even in their youth, acquire a color of a very dark hue. The Abyssinian mountaineers are as fair as the Neapolitans, or Spaniards, while the inhabitants of the plains are almost black. Among the Creoles, or Europeans born in Guiana, the women are distinguished from their sisters born in Europe, by the ebony hue of their locks.

Tribes of very different complexions are often found in immediate juxtaposition, because one or more of them are comparatively newcomers, on whom the climate has not had time to produce its full effect. Thus Americans of European descent are fairer than the Indians, because their ancestors were recent emigrants; and it is not unlikely that many of the native tribes removed from localities which favored a dark hue, and were not yet thoroughly blanched in their new situation. The Papuans are dark and curly-haired, because they entered Australia from tropical countries, which produced these peculiarities. The Alforians are probably the Papuans, modified by a longer residence in their new situations; as the Hottentots are, in all probability, only an earlier race of African settlers, whose peculiarities arose from long following a hunter life among the Karroos.

A cool, moist, and steady climate produces the fairest complexion. In a very dry and cold climate, the bleak winds, the rapid evaporation from the skin, and the intervals of very warm weather, darken the complexion. Hence the olive hue of the Mongols and Siberians; and hence the natives of the eastern sides of the two continents, are darker than those in the same latitudes on the western sides. The curling of the hair proceeds chiefly from the constant and often profuse perspiration to which the natives of the hot regions are subject. It is produced by the salts which the perspiration contains in abundance; and it answers the purpose of protecting the head more effectually from sun-strokes. The curling effects of common salt, (which is found abundantly in the perspiration,) is well seen in those whose hair is frequently wetted with sea-water. Those races who perspire least have the straightest hair.

The form and capacity of the skull, and the cast of the counte-

nance, are much more readily influenced by particular circumstances, than the color of the skin. Thus it is not uncommon to see a white man with features closely resembling those of the African; and we often see some of the latter, of a jet-black hue, with European countenances. The size and form of the whole head, seems to be little influenced by mere temperature directly. It affects them only by the habits and customs to which it leads. The weather, however, in connection with the modes of life, have a great effect. Thus a country swept by cold, piercing, dry winds, alternated with heat, produces, in those constantly exposed to the weather, flat faces and noses, large cheek-bones, and oblique eyes, as we find, both in the Mongols and in the Hottentots. Where, again, the climate is mild and steady, with an absence of high or cold winds, the features are remarkably regular, as in many parts of western Asia and southern Europe.

Food has much influence on the form and expression of the countenance; for where that is very gross and impure, the features are heavy, and the expression unanimated. Pursuits and habits have also a very powerful influence. When the inhabitants are occupied exclusively with their more pressing physical wants, and the gratification of the grosser appetites, the organs of the senses become unusually large, and the brain small. Hence the large mouth and projecting jaw, and the retreating forehead and compressed skull of the Guinea African. But among the Mandingoes and Gubers, where the Mohammedan religion has introduced some mental culture, and less debasing habits, the head exhibits a similarity to the Iranian form. The case of the Turks, already mentioned, is another striking instanee.*

We are told that negroes existed in the days of Rhamses III., or Sesostris, king of Egypt, and that national features appeared then as they do now. But according to Hale's chronology, which is allowed on all hands to be much more accurate than Usher's, the deluge happened 3,155 years before Christ, while Rhamses lived only 1,565 years before Christ; and therefore the intervening period of nearly 1,600 years was abundantly long to allow national peculiarities to appear. A much shorter period has sufficed to transform the Mongol Toorkman into the Iranian Turk, and the thoroughly Mongol Huns of the year of grace 888, into the completely Europeanized Magyars of the year 1850. When the circumstances and habits of a nation remain unchanged, instead of any approximation to others placed in different circumstances, their peculiarities are apt to become more and more striking with the progress of time.

* It is not a little remarkable that the head of a Turk—a man of Mongol descent—should be generally chosen as the best instance of the Iranian peculiarities; and that authors, in speaking of the superior beauty of this race, should refer to the Circassians particularly, another Mongol tribe.

§ V.—Longevity of Man.

It appears that the air of open and elevated plains and mountains is conducive to longevity. The same thing may be said of an insular atmosphere, which is always renovated by the breezes from the sea. Russia, Norway, Sweden, Denmark, Scotland, Ireland, and Switzerland, are countries which furnish the most numerous instances and the most authentic examples of men and women whose lives extended beyond the period of 100 years. One of the most remarkable instances in modern times is that of Colin McCrain, a native of the Isle of Jura, on the west of Scotland, who kept 180 christmases in one house, and appears to have lived several years beyond that age. In these countries we may reckon the centenarian for every three or four thousand individuals. But there are many other countries in which longevity is common. Pliny mentions that part of Italy which reaches from the Appenines to the Po, and from Placentia to Bologna, as containing, in the time of Claudius and Vespasian, a great number of men from 100 to 150 years of age. Examples of a life of 150 years seem to be common in most countries. England has furnished several examples of men who exceeded this period, such as Parr and Jenkins. Hungary, which is not a very healthy country generally, has produced many instances of great longevity. Czartazan lived to 185; and John Rivin to 172, with a wife 164, and a son 117. These all inhabited the Bannat of Temeswar, a very marshy district. A calm and temperate life, with regular habits and a pure atmosphere, appears to be best calculated to produce longevity; and therefore it is not improbable that in the ages of patriarchal innocence, the period of 150 or 200 years was more commonly attained than in our times—the simple mode of life, the absence of carking cares and disturbing passions, and living constantly in the open air, contributing greatly to this end.

It is sometimes supposed that cold climates are more favorable to longevity than warm: but, if we except marshy districts, this does not seem to be the case. Instances of great longevity seem to be as common as anywhere among the West Indian Negroes; and we are told of one negress who attained the age of 175. White men do not live long in warm climates because their constitutions are not adapted to them.

Among the causes unfavorable to health and longevity, may be mentioned luxury, intemperance, war, and indigence. Luxury and intemperance are injurious by inducing mental and corporeal debility, with a host of diseases: war selects the hardiest and strongest men, and consigns them to speedy destruction, while indigence ex-

poses its subjects to the evils of scanty and unwholesome diet, cold, close and damp dwellings, the want of proper medical treatment, and insufficient clothing. "The golden mean" seems best adapted to produce long life and exemption from disease. Thus we learn from the Statistical Journal (for March, 1845,) that the average duration of life, in England, at the age of 20, is 38 years for the peerage, and 40 for all England, while in the county of Surrey, which is inhabited chiefly by farmers, it is 42. In the city of London, it is only 36, and in Liverpool, 33. The evil results of poverty are seen from the average age of death among different classes in the county of Rutland, as given in the Poor Law Commissioners' Report to the British Parliament, in 1842. That of professional persons and the gentry, was 52; that of tradesmen, 41; and that of mechanics and laborers, was only 38. In the town of Manchester, the case was much worse, the ages of the three classes respectively being 38, 20, and 17; so that the average of the poor was not one half that of persons in comfortable circumstances. The state of matters in this country seems to be precisely the same. At Dorchester, (Mass.,) from 1817 to 1844, the average duration of life among the lowest class of operatives, was $27\frac{5}{12}$ years; among mechanics on their own account, $29\frac{1}{2}$; among merchants, professional men, and capitalists, $33\frac{2}{12}$, and among farmers, $45\frac{8}{12}$. The families are in all cases included.

It is a common opinion that the average duration of life has been decreasing constantly since the days of Noah to the present time. But this is by no means the case: — we have got far beyond the turning point; and it has been generally increasing throughout the civilized world for centuries, as we know from the funeral registers kept in various parts. In the city of Geneva, where such a register has been carefully kept for nearly 300 years, the mean duration of life has been steadily increasing since 1560. From that date till 1600 it was $21\frac{1}{6}$ years; during the next 100 years, it was $25\frac{3}{4}$ years; from 1701 to 1760, it was $32\frac{3}{4}$ years; and in 1833, it was $45\frac{5}{12}$, being more than double that of the first period. At Rome, the mean duration of the life of citizens, from the time of Servius Tullius, who died B. C. 534, to the days of Justinian, who died A. D. 565, is estimated at 30 years, while, among the corresponding class, in Britain, at the present day, it is fifty years. In 1801, the annual mortality, in Britain, was 1 in 44.8; in 1811, it was 1 in 50; and in 1821, 1 in 58. In London, the annual mortality in 1751, was 1 in 21; and in 1821, it was 1 in 40. Similar changes have been observed in France and Sweden. Owing to the more luxurious living, more dissipated habits, and less pure air of cities, the average duration of life is uniformly much less than in the country. M. Quetelet, in his work "On Man," gives, from a very

large collection of cases, the annual number of deaths in cities at 1 in 36.9, while in the country it was 1 in 46.9. Cities, however, differ widely in regard to longevity. Thus, at Philadelphia, the annual number of deaths is about 1 in 46, of the whole population; at New York, 1 in 38; at Boston, 1 in 41; at Paris, 1 in 32; at Rome, 1 in 25; at Amsterdam, 1 in 24; and at Vienna, 1in 22.

The increased duration of human life is undoubtedly attributable to a greater attention to the rules of health, and improved medical treatment of disease. As the laws of health are still very little understood or attended to by most of mankind, and they are now beginning to turn their attention to them, there is no doubt but future generations will attain a degree of longevity which many of the present would hardly credit, and which will render the great ages of the patriarchs no wonder to them.

It is a common opinion that winter is healthier than summer: but the sure test of a register shows that the case is exactly the reverse. M. Quetelet has shown that the greatest number of deaths occur in January, the coldest month, and that it diminishes regularly till July, the warmest month, when it again increases with equal regularity till January. This is true of the young as well as of the aged. Some epidemics prevail most during the summer: but all causes of death taken together are most powerful in winter. We formerly mentioned that the dry winds which blow from the African desert contain no poisonous gases: we may now further mention, in confirmation, that when the harmattan blows on the Guinea coast, all epidemics disappear, even small-pox; and in the Sahara, epidemics are almost unknown. Literary pursuits are generally favorable to longevity, always excepting those connected with the newspaper press.

§ VI.—LANGUAGE.

Man is the only creature that possesses an articulate language. This faculty of expressing ourselves by words which are the signs of our ideas insures the constant exercise of memory. Language, considered as a moral and physical faculty, appears to be innate in man's constitution, but the choice of sounds and their modifications, must have depended upon his will. Natural logic has unquestionably had its influence; and in addition to it, the passions of individuals, their habits, the delicacy of their organs, the nature of the climate, and the state of society, would all contribute to promote these effects.

The primitive tongues, possessing a very scanty stock of words, simple as the manners of those who spoke them, would naturally be lost,

by becoming confounded with the more perfect dialects which sprung from them—just as the primitive nations have disappeared by merging in those nations celebrated in history, to which they had originally given birth. Although the attempt to discover the primitive tongues appears to have been abandoned, philologists still do not despair of fixing the number of mother tongues; that is, of those which, in their vocabulary and grammatical structure, present to us a character independent of every other tongue. These mother tongues, as they suggest the possibility of a common origin, from their evincing some distant traces of resemblance, form among themselves families, without any of them being able to claim pre-eminence in point of antiquity. We shall first mention that history clearly proves that the Hebrews, Indians, and Greeks, were at least as ancient as the Ethiopians, Celts, or Chinese.

§ VII.—Indo-Atlantic and Detached Languages.

The *Sanscrit* prevailed anciently from one end of Hindostan to the other; and most of the spoken dialects of that country are descended from it. The Sanscrit itself has long been a dead language; but it is very interesting to the philologist on account of its high antiquity, and its connection with the languages of ancient and modern Europe. Besides a certain number of roots, or original words, which the Sanscrit has in common with the Greek, the Latin, the Gaelic, the Welsh, the Sclavonic, and the Germanic tongues, it displays also, in its numerous declensions, and its extended conjugations, the most striking affinities to these mother tongues of Europe. This is the language of the sacred books of the Brahmins. The *Bali*, said to resemble the Sanscrit, is the sacred language of the Boodhists, who are found in southern and eastern India, Thibet, and China.

Persia presents us three ancient languages. The *Zend*, which appears to have been the language of ancient Media, is the sacred language of the Guebres. The *Pelhevi* was the language of ancient Persia; and the *Parsee* was a more modern dialect, whence chiefly descended the present *Persian*, which is, however, intermixed with many Arabic words. It has also lost most of the inflections of the older languages. The *Koordish* is a very ancient language, still spoken, similar to the Zend.

The *Greek* tongue belongs to those of which we know well the different species. The Greek had four dialects. The *Doric* was spoken in many parts of northern Greece and the Peloponnesus, and by the Doric colonies in Sicily, Italy, and Asia Minor. It was a rough dialect, and contains only the works of Pindar, Theocritus, Bion and Moschus, with a few fragments. The *Aeolic*, which closely

resembled the Doric, was spoken in Aetolia, Thessaly, Bœotia, and Aeolis in Asia Minor. It contains nothing but a few poetical fragments. The *Ionic* was spoken in Ionia, a Greek colony in Asia Minor, and in the isles adjacent. It was a very rich and harmonious dialect. This is the dialect of Homer, Hesiod, Herodotus, Hippocrates, and Apollonius of Rhodes. The *Attic*, which originally agreed with the Ionic, but afterwards greatly differed, was spoken only in Attica, the district containing the city of Athens. This is the dialect of all the distinguished writers not already mentioned, such as the tragic poets, all the orators and philosophers, Thucydides, Xenophon, Polybius, etc. After the time of Alexander the Great, this dialect, slightly altered, was written and spoken generally throughout the Grecian territories; and all authors used it exclusively, except a few epic poets, who used the Ionic. It was this Attic dialect that was spoken in Palestine in our Saviour's time, intermixed with several foreign words and idioms, derived chiefly from the Syro-Chaldaic, still commonly spoken by the Jews, and from the Latin, spoken by the Romans, who ruled the country. The Greek language excels, in copiousness, precision, and harmony, all other ancient languages; and the immense treasures which it contains render it the most important of them. Among these, we must mention the New Testament, the whole of which was written originally in that modification of the Attic dialect which we have just described, and which is sometimes termed *Hebraic*, and sometimes *Hellenistic* Greek. The Attic Greek was spoken with some degree of purity at Constantinople, by the educated, till that city was taken by the Turks in 1453. After that time, it was so much corrupted as to be called by another name. It is now termed *Romaic*, a dialect spoken not only in Greece and its isles, but by the Greek inhabitants of Turkey, who number several millions.

The *Latin* has generally been considered only a dialect of the Greek; but a more careful and extensive survey has dispelled this illusion. It has in fact preserved old forms much better than the Greek. It is not, however, an unmixed language; for it contains many Cymraeg, or Celtic words, derived probably from the Sabines, who were a Celtic race.* It also contains several words borrowed from the Greek. The Latin was spoken originally only in the western part of central Italy; but the conquests of the Romans introduced it into Gaul, (now France,) Spain, Portugal, and some parts of Germany and Turkey. It was the general language of the learned throughout Europe, from the sixth to the sixteenth century; and it is still very frequently employed in learned treatises. It is generally called a dead language; but this is true only in one sense; for it is still

* See an elaborate proof of this, by Archdeacon Williams, in the *Transactions of the Royal Society of Edinburgh.*—Vol. xiii. pp. 494 to 563.

spoken by many, even of the common people, in Hungary and Poland; and it is a very frequent medium of intercourse in Turkey, being almost the only European language that is acquired by any considerable number of the Turks. On account of the extensive treasures of learning which it contains, and the very extensive influence it has had in the formation of modern languages, it is the most important language of ancient Europe, next to the Greek, over which it possesses the advantage of containing no variety of dialects. It seems to have been introduced into Italy from the eastern Alps, by a branch of the Indo-Atlantic race called *Pelasgians*, who were also the principal progenitors of the Greeks. The *Skype*, or *Albanian*, still spoken by the Arnauts, appears to be another Pelasgic language. Another language of the same stock is the *Gaelic*, the language of Ossian and his heroes, still spoken in the Highlands of Scotland, the Hebrides, and a great part of Ireland and the Isle of Man. This language is often classed with the Cymraeg, but it differs very widely, and bears a closer affinity to the Latin. It was introduced into Scotland from ancient Belgium, whither it appears to have come from the same quarter as the Latin into Italy; and from Scotland, it passed into Ireland, where it superseded the Cymraeg, which was spoken there before. In Scotland, it adopted some Cymraeg and Scandinavian words.

The *Cymraeg*, or *Celtic*, was the language of the Gauls, so conspicuous in the Roman annals. It is still spoken in Bretagne, a province in the west of France, under the name of Armoric or Bas Breton, and in the principality of Wales. It was formerly spoken in the south-west of England, but became extinct there a little more than 100 years ago. This dialect was called the Cornish. The Cymraeg is probably the first Indo-Atlantic language introduced into Europe.

In the Basque provinces, in the north of Spain, and in the south-west of France, are spoken dialects of a language which has been often classed with the Celtic, called the *Basque*, or *Guipuscoan*. But it does not belong to the Indo-Atlantic languages at all. It is a remnant of the language spoken by the Iberians, or first inhabitants of Spain and Potugal, and was probably introduced from Africa. It will likely be found allied to the language of ancient Mauritania or Morocco. Some of the Iberians seem to have found their way into Britain and Ireland before the Celts entered them; and these appear to have borrowed some words from their language. The Silures of South Wales are thought, by Tacitus, to have been an Iberian race; and the stories of the Milesians in Ireland, probably owe their origin to Iberian colonies. These were blended with the Celts.

Some of the most important languages of modern Europe are those descended from the Latin. The *Italian* is spoken through all

Italy, a part of Switzerland, and in several of the isles of the Mediterranean. A corrupt dialect of it, called *Lingua Franca*, is spoken in the sea-ports of the Levant. It is Latin, with the words contracted and softened, and mixed with some German and Greek words. The *French* is spoken throughout most of France, a great part of Belgium, and the north-west of Switzerland. It is the common language in Lower Canada; and it is not yet extinct in New Orleans. It is very much used all over Europe, as the language of courts; and it abounds with profound scientific works. It is Latin, intermixed with Celtic, Gaelic, and German words, and greatly abbreviated in the pronunciation. The *Spanish*, or *Castilian*, is spoken throughout Spain, except in the Basque provinces, in Mexico, Central America, Cuba, Porto Rico, and all the European settlements in South America, except Brazil. The Spanish resembles the Latin more than any other language sprung from it, although it contains Basque, Celtic, Gothic, and Arabic words. The *Portuguese* is little more than a dialect of the Spanish: it is spoken in Portugal and Brazil. The *Wallac*, or *Roumoneek*, is another Latinic dialect, intermixed with Greek, Gothic, Turkish and Slavonian words: it is spoken in Wallachia, Moldavia and Transylvania. All the languages sprung from the Latin have greatly altered the inflections and syntax of the parent language. Last, but not least, of this class of languages, we must mention the *English*. The original basis of this language was the Saxon, anciently spoken in the north of Germany: but that tongue was much altered by the dialects of the Jutes and of the Angles, who belonged to the Scandinavian race. The Danes afterwards introduced more Norse. It also borrowed many words from the Cymraeg and Gaelic of the earlier inhabitants of Britain. This fusion produced the British Saxon, or Anglo-Saxon. The conquest of England by the Normans, in the 11th century, introduced a very great number of Latin words, in a French form; and the use of Latin by churchmen and lawyers, introduced many more during the middle ages. These changes, accompanied with equally extensive changes in the grammar, altered the language, and produced what is called, rather improperly, *English*. The language of the Angles forms only a small part of it. Many words are still Saxon; but a much greater number is Latin.* A great number even of the common terms are taken from this language,—such as mountain, river, ocean, air, uncle, aunt, nephew, niece, &c. Since the revival of learning myriads of additional words have been introduced, chiefly

* It has often been said that most of the English is Saxon; but if any person will take the trouble to count the words in a Saxon and an English Dictionary, and make allowances for Saxon words dropped, and for other words besides Latin introduced, he will find that the Latin words are at least three to one.

from the Latin, and partly from the Greek, French, &c., so that, if not a very uniform, it is at least a very copious language; and it bids fair, in the course of a few centuries, to be spoken by more people than any other language in the world. It differs from the French, Italian, &c., in having a Germanic foundation. Its literature is extremely rich and valuable, in almost every department, and distinguished for sound sense, and an absence of dreamy speculation. The language is well adapted to every kind of subject. Altogether it is the most important of living languages, and is likely long to continue so.

Of the Slavonic tongues, which are spoken over more territory than any other European language, there are two classes: the south-eastern and the north-western. To the former, belong the *Russian*, *Rusniak*, *Bulgarian*, *Servian*, *Bosnian*, *Dalmatian*, *Croatian*, and *Wendish*: to the latter, the *Polish*, *Silesian*, *Bohemian*, *Moravian*, *Slowakian*, and *Sorbian*. To the Slavonic tongues belong the ancient *Lettish*, and *Lithuanian*. The literature of all these languages is not very extensive, or of much general importance.

In the class of Germanic tongues, a very ancient division is perceived. The *Frisian*, or *Dutch*, *Saxon*, *Anglo-Saxon*, and *German*, form the Teutonic branch, to which also belonged the ancient *Maeso-Gothic*, whilst the *Icelandic*, or *Norse*, the *Swedish*, and the *Danish*, constitute the Scandinavian branch. The German is spoken through most of Germany, in German Austria, the eastern part of Switzerland, and some of the French departments on the Rhine. It is very rich in works on languages, divinity, history, and antiquities. The Dutch is spoken in Holland and its colonies. The Saxon, and Anglo-Saxon, may be considered dead languages, although the spoken dialects of northern Germany greatly resemble the Saxon. The Icelandic, or Norse is spoken in Iceland, and the more remote and rural parts of Norway. The Swedish is chiefly confined to Sweden; it differs very little from the Danish, spoken in Denmark, and the more populous parts of Norway.

In the north-east of Europe, we discover scattered remains of the great Scythian tribe of languages. To this class belong the *Lapponic*, and the *Finnish*, together with the *Esthonian*, the *Livonian*, the *Permian*, and various other dialects, spoken along the Uralian Mountains, and the Volga. The *Hungarian*, or *Magyar*, originally from the neighborhood of the Caspian Sea, is said to exhibit a great family likeness to these languages.

The Caucasus, situated in the centre of those regions where the Indo-Atlantic languages prevail, far from presenting to us the common source whence these derived their origin, interrupts their chain; and, in the Georgian, Circassian, Armenian, and some other dialects, furnishes us with a distinct family, or rather group, of languages,

little known, but unquestionably of great antiquity. The Circassian is of the Tartar class, and the Armenian is related to the Indo-Atlantic.

§ VIII.—Aramaic or Syro-Arabic Languages.

If we extend our view to Syria, Mesopotamia, Arabia, and Abyssinia, the Aramaic or Syro-Arabic languages draw our attention, by the renown of their ancient civilization, the abundance of guttural sounds, multiplied inflections, vast store of words, and general simplicity of structure. Such appear to be the characteristics of these tongues.

The *Arabic*, with all its descendants, occupies the widest field. Dialects of it are current all over North Africa and the Sahara. It is the language of the Fellahs, who form the main population of Egypt. The *Gheez* and *Amharic* dialects are spoken in Abyssinia, and different branches of the Arabic extend along the eastern coast of Africa. It is spoken throughout Arabia; and by means of the Koran, it has spread through Turkey, Persia, Tartary, and India.

The *Hebrew* was spoken by the people of that name till the Babylonish captivity, soon after which it became a dead language. After their return from captivity, the Jews spoke Syro-Chaldaic, although, after the time of Alexander, Greek became common. The learned among the Jews continued to write and speak Hebrew almost to the present day. It is an impure dialect, termed *Rabbinic*. The *Syro-Chaldaic* was nothing but *Chaldee*, intermixed with some Hebrew peculiarities; and indeed it differed so little from Hebrew that it might almost be called a dialect of the same language. It is this Syro-Chaldaic that is called Hebrew in the New Testament. The Chaldee was spoken in Chaldea and Babylonia, down to modern times; but it is now extinct. The Old Testament is all written in Hebrew, except a few chapters and verses in the books of Ezra, Jeremiah, and Daniel, which are in Chaldee. The ancient *Syriac* differed so slightly from the Chaldee that it was essentially the same language; the latter was called *East-Aramean*, and the Syriac the *West-Aramean*, *Aram* being the vernacular name for Syria. It was spoken throughout Syria and Mesopotamia. It is still spoken in these regions, though not exclusively, and also among the Nestorians, in Persia; but it is so much altered that the ancient language is unintelligible to the common people. The Aramean language resembles the Hebrew more closely than the Arabic does; and hence it is of more use in illustrating the Old Testament. But as the literature of its two dialects is scanty, while that of the Arabic is abundant, the latter is more studied by scholars.

The *Samaritan* dialect, spoken by the Samaritans, is essentially the same as the Syro-Chaldaic, but contains a larger intermixture of Hebrew. It is now nearly, if not quite, extinct.

The *Phenician*, spoken in ancient Tyre and Sidon, of which the *Punic* or *Carthaginian* was the most celebrated branch, was also an Aramaic language; and the low Arabic Maltese is thought to preserve some remains of this dialect. There is nothing extant of the old languages except a few inscriptions.

As some of the nations that spoke the Aramaic languages descended from Shem, this stock is sometimes distinguished by the name *Shemitic*, while the name *Japhetic* has been given to the Indo-Atlantic languages. By admitting this denomination, we are obliged to attribute to the descendants of Ham all the other languages on the face of the globe, from the Tschudic to the Mexican, though we know the Canaanites and Phenicians, Ham's descendants, actually spoke dialects of these, so called, Shemitic languages. The terms are improper; and they are beginning to be laid aside.

§ IX.—Monosyllabic and Tartar Languages.

The languages of eastern Asia are chiefly of the Monosyllabic class, and differ very widely from that of the Indo-Atlantic. They comprehend the *Thibetan*, the *Chinese*, the *Burman*, or *Avan*, the *Peguan*, the *Siamese*, and the *Anamic*, which is the language of Cambodia, Tonquin, and Cochin China. All these languages are more or less deficient in contrivances for marking the cases, genders, numbers, moods, and tenses. Those who speak the mare obliged to supply the absence of grammatical forms by intonations and gestures.

To this class belong the *Corean* and *Japanese*, both of which closely resemble the Chinese. The *Pooshtoo*, or Afghan language, is peculiar, and probably has an affinity to the Aramaic.

The north of Asia contains three or four kinds of languages, said to be superior to the preceding class. The *Toorkman*,* *Bucharian*, and different kindred dialects, are spoken from the Crimea and Casan to Tobolsk and Samarcand, and in several parts of Persia. These are termed the *Turco-Tartarian* languages.

The *Mongolian* language, which is said to be deficient in grammatical combinations, but to possess complete declensions, and to abound in vowels and harmonious sounds, is spoken by the Kalkas, Eluths, and Kalmucs. The *Muntchou*, or *Mandshurian* language, though full of monosyllabic words, is said to possess a very complete and varied grammatical structure. The *Tongusian* is a kindred dialect. These are spoken through eastern Tartary and cen-

* The *Turkish* is only a dialect of this language.

tral Siberia. The three preceding classes are all related. The first might be called the *West Tartar;* the second, the *Central Tartar;* and the third, the *East Tartar.* Through northern Siberia are spoken several languages—such as the *Samoyede*, *Yakut*, and *Koriak*. These are said to be related to the Tartar and Finnish languages: but we possess very little reliable information regarding them.

§ X.—Oceanic and African Languages.

The Oceanic countries, from Sumatra to the Marquesas, present us with a series of dialects which have all a relation to the *Malay*—the language of Malacca. Dialects of the same kind are found in Madagascar, among the Malagaysy. The *Tagalic*, and the *Bisago*, of the Philippine Islands, are found in the Molucca and Marian Islands; and traces of them are found in New Zealand. Dialects of a language termed the Tahitian are distributed through the small islands of the Pacific Ocean. More to the west, the Papuan tribes of New Caledonia, Papua, Australia, and Tasmania, speak dialects which form a separate stock. These languages present a more finished structure than the condition of those who speak them would lead us to expect.

The languages of Africa are little known, comparatively speaking, and have appeared innumerable to strangers and travellers. But this opinion arose from the difference of pronunciation. The languages of Benin, Congo, Dahomey, and Nigritia, present the same combination of consonants, and many common words. The language of the Berbers, in the north of Africa, appears to be the remains of one spoken along Mount Atlas, and the Mediterranean, in very early times. The *Coptic*, a remnant of the ancient Egyptian, is well known. South of the Mountains of the Moon, all the languages, except the Hottentot, are similar, and distinguished by the great prevalence of the initial *mp*. They are termed the *Mpongwe* languages.

At the southern extremity of this part of the world, the Hottentots speak a peculiar language, full of clickings and shakings of the tongue, which produce sounds similar to the cries of small birds.

Recent researches lead to the conclusion that all the African languages (omitting Arabic dialects) are so closely connected as to form one class, and that they have a marked affinity to the Aramaic languages.

§ XI.—American Languages.

Humboldt thinks that a great number of the American languages are independent of one another. But subsequent researches lead to a different conclusion. They all exhibit the polysyllabic structure. An immense number of single words is strung together to form one, so that, as John Eliot said, "they seem to have been growing since the creation." They are therefore classed together as the *Polysyllabic Languages.*

The Toultec, the Huaztec, and the Aztec, were successively current in Mexico, before its conquest by the Spaniards. These languages, in which a laborious search has been made for some affinities to the Mongolian languages, are extremely complicated, both in their etymology, and their syntax; and the same remark applies to many of the American languages. The Aztec is the most prevalent in Mexico at present. The *Cherokee*, *Iroquois*, and *Algonquin*, or *Huron*, appear to be the most widely extended of those that are spoken between Hudson's Bay and the Gulf of Mexico. These are comparatively meagre and plain, though by no means simple. The Iroquois is remarkable for the total absence of labials. The *Esquimaux* or *Karalit*, which is current over the polar region, has been found to be the same as the Tschudic of eastern Siberia. In South America, the *Caribbee*, a sonorous language, prevails to the north of the River Amazons, as it did formerly in the West Indies. Several ancient dialects, regular in their composition, have disappeared, in New Granada, Quito, and Peru. But the *Quichua*, the language of the Incas, remains in general use among the Peruvians, and in the adjacent regions. The *Guarran* language is so prevalent in Brazil and Paraguay, that the Spaniards and Portuguese, even in several of the towns, speak no other. Different dialects, little known, exist in Chili, and in Patagonia. The *Araucanian* of southern Chili is said to be remarkably rich and harmonious. The Petcheres, in Terra Del Fuego, have a dialect peculiar to themselves.

The late Mr. Duponceau, who examined the American languages long and attentively, declared them astonishingly copious, and complex in their structure. They are also said to be much less irregular in their forms than European languages.

§ XII.—Number of Languages.

In the preceding sections we have passed under review all of the principal languages spoken by the human race. How wide the dif-

ference in the scale between the Chinese and the Greek. For the first does not distinguish the singular from the plural, whereas the latter expresses the most subtle and profound thoughts, with precision and energy.

There are languages, again, which have no words to express imperceptible objects, such as God, and the soul.

The whole number of languages in the world has been very variously estimated. One enumeration makes 876 languages. Of these, 153 belong to Asia, 53 to Europe, 115 to Africa, 117 to Oceanica, and 438 to America.

Another computation, however, makes their number as follows:—to Africa 276, to Europe 545, to Asia 991: the total 3,026, including Oceanica.

But of these, only 72 original languages are enumerated by others, the preceding number being made up by counting mere dialects as distinct languages.

There are only 12 languages which are known to be spoken over a great extent of country, or by a great number of persons, viz.:—5 Asiatic—*Chinese*, *Arabic*, *Turkish*, *Persian*, and *Hindustani*; 5 European—*English*, *French*, *Russian*, *German*, and *Spanish*; one African—the *Mpongwe*; and one Oceanic—the *Malay*.

§ XIII.—Social Condition of Nations.

With respect to the condition of society, nations may be distributed into three classes—*savages*, *barbarians*, or *half-civilized*, and *civilized*. Every class admits of various degrees.

Savages are those who are ignorant of the arts connected with civilized life, of writing or of communicating their thoughts by means of conventional signs, of the art of calculation by numbers, and of everything that can properly be called science. Worst of all, they are ignorant of their own origin and future destination, of the laws which govern their nature, and of the true character of its Divine Author. They are like children in point of character; and their vague, unsteady ideas are attached only to objects which strike their senses. But their particular customs and modes of life greatly vary. Some cover themselves with rude ornaments, while others wear hardly any. Some are passionately fond of dancing and rude music, of the chase, and also of athletic games, such as ball-plays and foot-races; and some have national war songs to stimulate their y[illegible] to battle, and war dances, in which, with many grotesque [illegible]ge previous to leaving home, and after their re-[illegible]veral of the Indian tribes have also a time of [illegible]en the maize or Indian corn is ripe, which they

celebrate by a particular kind of dance, called "the green corn dance." Others appear to have scarcely any hilarious exercises.

In all that requires mere physical endurance and suffering, the Indians were formerly supposed to surpass civilized nations, especially in the power of abstaining from natural food, whenever it became necessary to attain an object by doing so. But a closer acquaintance with them has shown this opinion to be erroneous: the white trapper, in this respect, excels the Indian. Yet the latter supports pain with a degree of insensibility which must be attributed to greater obtuseness of sensation. Their industry is usually confined to a little gardening, to fishing, and especially to hunting; for the chase constitutes not only their chief amusement, but their principal mode of livelihood. They exhibit also great ingenuity in the manufacture of articles of domestic use; as pottery, bead-belts, baskets, hammocks, moccasins, and implements of war. Their wisdom might be considered as manifesting itself chiefly in council, where they assembled to deliberate upon the most effectual methods of attacking their enemies, whom they pursued in the most crafty and stealthy manner; they frequently surprised them under cover of the night, and consigned their sleeping families to the horrors of conflagration, perpetrating on their captives the most shocking cruelties. Such atrocities have fortunately passed away, with a few rare occurrences. Some savages devour their enemies, others mutilate and even impale them, and some sacrifice them to their idol gods. Yet even the most savage and degraded exhibit some traces of the immortal mind.

It is instructive to compare the taciturnity, resolution and constant feelings of the North American Indian, with the loquacity, irresolution and fickleness of the Polynesian. This shows how worthless are the minute descriptions applied by many authors to all savages. In no condition shall we find such striking differences, both of circumstances and character.

The class of barbarians, or half-civilized nations, comprehends every one which, by possessing a knowledge of writing, and several of the more useful arts, with some traces of science, have evidently emerged from the savage state; but the knowledge which such a nation possesses, is as yet an indigested mass of incoherent observations; their arts are exercised, as it were, by routine,—their policy is limited to the defence of their frontier, at the moment of danger, or to offensive operations conducted without a plan. Their progress is, in general, slow and uncertain; because, even in advancing towards civilization, they have no proper conception of the great object at which they should aim. The most civilized nations regard the Turks, Chinese, and Russians, in the light of barbarians:—yet, perhaps, they are not so inferior as national self-conceit leads others

to suppose. Nations are very partial judges of their own social position;—and if the Spaniard be civilized, the Turk is not a barbarian. A civilized nation is one who has arranged its knowledge into the form of sciences; and who is governed by laws, instead of brute force and violence. The best criterion ever given, is that of Thucydides, who considers a nation civilized when men can go unarmed, because the law protects them; when they go armed for defence, they are, at least, barbarians. But high and thorough civilization can be obtained only by a nation in which Christianity, undefiled by superstition or enthusiasm, displays its proper influence, in the purification and elevation of the public morals;—and who, consequently, in its intercourse with others, recognizes the great principles of justice, by acting in time of peace as the friend of every other state, and by respecting, in time of war, the property of defenceless citizens, and abstaining from all deeds of violence which do not tend towards the main object of the contest.

§ XIV.—Influence of Country upon the Character of Nations.

The nature of a country has, in the estimation of many, a decided influence upon the virtues and vices of its inhabitants. It is said, for instance, that nations who live in a very rigorous climate, are habitually more addicted to the use of strong and inebriating liquors, than those who reside in a temperate, or even a hot region. The northern nations are also said to be constitutionally less liable to intoxication, and to drink much larger quantities of strong liquors, without being ruined in their health and morals, than the inhabitants of countries which are exposed to the influence of a scorching sun. This has been said to be owing to the caloric, or natural heat of the body, being strenuously acted upon by the atmosphere, and passing off more rapidly, and in greater quantities, from their systems, thus leaving, in its absence, a frigidity and debility which could not easily resist the action of the cold upon the limbs, and therefore required to be more or less supplied by artificial means. But our present knowledge of the action of alcoholic liquors, and the experience of arctic navigators, render this explanation ridiculous. Instead of alcohol being beneficial in extremely cold countries, there are many instances where a single glass of brandy cost the person who drank it his life; and in the polar regions, total abstinence from all intoxicating liquors is rigidly enforced among seamen. Alcohol is immediately less dangerous in cold countries, owing to the more rapid escape of heat; but for that very reason, it is more dangerous when the reaction sets in. It is also found, that intoxicating liquors are

quite as much used in warm as in cold countries. So, we had an elaborate explanation of a fact which never existed, except in the imagination.

The northern nations are supposed to occupy a most elevated rank in the scale of lofty and severe acquirements, in all the exact and more abstruse sciences, and are celebrated for their habits of laborious application, and even painful study,—whole lives being often passed in entire devotion to the attainment of one single branch of a subject. Instances of this are common among the Germans. Yet if we look at the extremely little real progress that has been made in many of the most important sciences, since the times of the ancient Greeks, we shall, perhaps, be apt to conclude, that more vigorous thought, with less plodding and mechanical study, would have been better. It is remarkable that many of the most profound works—such as Newton's Principia—were written without any painfully protracted study.

Southern nations are supposed to excel in the fine arts, to possess a melodious voice, a delicate ear, and musical taste; a rich, harmonious language, exquisite refinement of sensibility, and luxurious propensities, a superb configuration of form and feature, rich tints of beauty both of eye and complexion, and masses of flowing, or curling ebony hair,—and to be so indolent that even amusement becomes a toil; while they indulge in sunny ease, light spirits, and buoyant feelings, which partake of the character of their sparkling skies and mellow clime—gaiety being better understood and appreciated here than in the heavy and gloomy atmosphere of their northern brethren, who have neither leisure nor inclination to bestow upon the lighter pursuits, or innocent recreations of life, and content themselves with being the manufacturers and merchants of knowledge, and of the mechanic arts, for the whole world. Yet this is only an instance of hasty generalization: and if we compare the plodding Chinese of Canton, within the torrid zone, with the Russian of Petersburg, near the arctic circle, we find the case, in a great measure, reversed.

The affections and imagination of the southern nations are said to be more lively and more ardent than those of the north; and the genius which distinguishes them, of a more poetic, tender, and romantic character, than that of the inhabitants of a more rigorous climate; whilst colloquial talents, a graceful oratory, and a varied and powerful fancy, shed a lustre upon their manners, which confers upon them the palm of elegance in social life. But we believe the negroes of Guinea, and the Indians of Brazil, are rather deficient on most of these points, though they live directly on the equator. They are certainly inferior, in these respects, to the Icelanders.

France is peculiarly distinguished for her patriotism, and her victories, her poets, metaphysicians and philosophers, her chemists, and

her astronomers, and for being one of the most highly adorned and smiling countries on the face of the globe. All nature smiles there, and amiability appears to be the national characteristic. The air sparkles with wit, within the brilliant circles of the Parisian world, and life, happiness, and improvement, seem to invite the beholder to live forever. The noblest institutions devoted to science and education, which are munificently thrown open for the benefit of the whole world, enrich the precincts of this gigantic emporium, on every side; and the faithful votary has only to pluck the fruits that hang so temptingly from the tree of knowledge, at every step, and sweetly realize his own immortality. Yet the picture has a repulsive reverse: for we find friendship is often professed, where it is not felt; and the strongest apparent feelings and professions of to-day, are no guarantee for the conduct of to-morrow.

Some of the preceding observations may teach the young reader to beware of beautiful theories, which do not accord with facts. If we calmly look to these, we shall soon see the real state of the case in regard to climate. In cold countries, the difficulties with which man has to contend, render him active, thoughtful, and circumspect; and he will not squander what he laboriously acquired. If the climate be extremely severe, it may require nearly all his energies to enable him to preserve his existence, in which case he will exhibit very little general mental culture. In warm regions, the earth produces so abundantly, and so little shelter or clothing is required, that there is much less stimulus to exertion, and much more time can be devoted to amusements, and mere accomplishments, if people are so minded; and men will be prodigal of what cost them little toil. But as all cold and warm countries are not alike, neither are the inhabitants. That mere heat and cold have very little influence on character, must be evident when we reflect that the inhabitants of cold countries generally live in a temperature as high as the average of many warm countries. Thus the citizen of New York sits in winter beside his stove, in a temperature of about 70°; while he of New Orleans, at the same time, sits with open window, in a temperature of 63° or 64°. If one should point us to the cold and distant manners of the Laplander, and compare them with the gaiety and warmth of the Italian, we simply require him to compare the sprightly, hilarious Norwegian, with the stern, unbending, and ungenial old Roman. To arrive at truth, we must view both sides of a question.

The lofty mountains of Switzerland, in their snowy mantles, the sparkling glaciers, and the placid lakes, that adorn this beautiful region, seem to have imparted a portion of their own superior excellence to the moral development of the beings who live in hourly contemplation of their charms; whilst they appear to have been intended as a natural barrier to shield innocence from the contami-

nation of a depraved and turbulent world; and elevate to a nobler standard, the simple faith that has so long distinguished the children of this happy land, and preserved in its peace and purity, the religion of their fathers, amid the storms of persecution that assailed and threatened to overthrow this beautiful monument of a nation's glory. The happiest example we can offer of the true Swiss character, is to be found in the life and labors of the celebrated Oberlin, a preacher of the Protestant faith, who lived and died in the service of his parishioners, among the mountains and glaciers of the High Alps of Switzerland, in the daily exercise of the purest and deepest principles of the Christian faith, exhibiting in a luminous aspect, as through a mirror, the strict self-denial and practical doctrines of the first apostles of Christ.

Being above the evils of penury, and not above the necessity for daily toil, while they are not crushed by the iron rod of oppression, the Swiss character affords the most numerous and genuine specimens that remain to us of the primitive purity of habits and manners that belonged to the first ages of the Church, and so beautifully described by the early poets, as characteristic of the golden age of antiquity, which doubtless referred to the days of patriarchal simplicity, when the wants and devices of man were few—when gold had not yet become a god, and virtue exceeded vice—when pastoral life furnished occupation, livelihood, and happiness to its quiet possessors —and while the hourly associations of men's minds were confined to the glorious firmament, the seasons and their varied influences, and to all the other magnificent works of creation through which they read, as in an ample volume, the wonders and the love of the munficent Creator of all; and served and worshipped Him for Himself alone, yielding Him the unaffected and fervent homage of the heart and the understanding.

The Swiss peasantry may be called the shepherds of Europe; their time being chiefly devoted to tending and rearing flocks and herds, and manufacturing butter and cheese for foreign consumption. Another class of the community are remarkable for their skill in the construction of clocks, watches, metronomes, and various other pieces of mechanism for the exact measurement of time, and also of musical instruments—especially that delightful little instrument, the accordion, which, in the wild melody of its tones, seems to have imprisoned passing mountain echoes, to let them escape at will. The grand, varied, and delightful scenery which surrounds them, seems to exercise an elevating influence on their character; and we find them exhibiting integrity, contentment, industry, an ardent love of the charms of nature, bravery, and a passionate attachment to their native mountains and valleys, and the romantic music of the peasant's horn, echoing through the precincts of their beloved homes, and which,

heard on a foreign strand, is said to melt the soldier to tears, and produce such an influence upon his feelings, that the air has been prohibited among some of the Swiss regiments serving abroad, lest it should lead them to desert for home.

The favored soil of Greece, from the earliest periods of literary antiquity, until the subjection of her gifted sons beneath a foreign yoke, furnished a rare example of the brave and the beautiful, the noble and the tender, the elegant and the profound.

Such are the fruits of liberty. Had the Swiss been subdued by the Austrian in the middle ages, or had the Greek of old bowed his neck before the Persian, we should not to-day have so much to say of their virtues. Nor were the brave deeds of Tell or Leonidas beneficial only to their own contemporaries. The memory of their ancestors animated and sustained the Greeks of the present day, in their recent dark but successful struggle with the haughty Ottoman; and should the liberties of Switzerland be now threatened by foreign despots, the recollection of their fathers' valiant deeds would steel their arms to defend their country's rights, and maintain the blood-bought liberty left them as an inheritance.

Tyrants should know that no time will efface the memory of liberty. The Greeks, in spite of the yoke of tyranny under which they were oppressed for 2,000 years, exhibited in their recent dreadful struggle with a barbarous foe,* the manly character and republican spirit of their ancestors, of whom they proved themselves no unworthy descendants.

The small town of Parga, whose unmerited catastrophe is an everlasting disgrace to those who effected it, repeatedly presented the spectacle of women taking up arms to fight for liberty. We know that Byron wrote—

"'Tis Greece, but living Greece no more!"

This line displays the black heart of him who penned it. Greece is living—a free, independent country, after having performed deeds not unworthy of her best days; while Byron's grave contains the remains of one who died in the prime of life, the victim of debauchery! He found the Greeks would not fall down and worship *him*, or even elect him king, or general-in-chief, (for either of which he was totally unfit,) so he must vent his spleen by croaking Greece was dead! † a strange way, truly, of assisting the Greeks, while contending against such fearful odds.

* We are all well aware that the character of the Turks has been called by some who profess to guide public opinion, "very respectable." The massacre of Scio is a sufficient answer. It is well that the Turkish power is now a nonenity, though we hope the barbarous Russ is not to succeed to it.

† We think it is much to be regretted that this man's autobiography was not published, instead of being burnt, and that Thomas Moore did not give all

Mountains, rivers, and forests, probably directed the course of the first tribes in their emigrations; and having influenced their physical and moral character, have also given rise to the first geographical divisions and denominations. But what has most accelerated the extension of the human species, and the progress of civilization, is the invention of navigation.

What lively and strange emotions must the first men have felt, when, descending from their paternal mountains, after having wandered in the thick forests which covered them, they saw their further advance impeded by an immense plain of water, which, in the distance, appeared to be lost in the sky, and to mingle with the clouds! From observing sea-fowl on floating logs, they probably learned the art of constructing boats, and finally large vessels, with sails and masts. Experience and enterprise gradually taught them the art of navigation, which in the lapse of time, civilization and increased knowledge reduced to a systematic art of an important character, upon which became established the respectability and power of nations, and the rank they held over others, their success in war, their wealth, and their enterprise in founding colonies, and finally, their aggrandizement by means of commerce. Interior nations were of course precluded by their situation from obtaining any power or being influenced by such means.

The fate of great human families has been decided by the direction taken in their emigration; by the nature of the soil they occupied; but above all, by the position of the great seas of the globe, and by the advantages which men derive from them. May not the perpetual infancy of the Chinese be owing to their ignorance of the art of navigation?

On the contrary, if the Japanese and Malays exhibit a character, manly, enterprising, and different from that of other Asiatic nations, it was formed at the epoch when their squadrons traversed the great Eastern Ocean, or Pacific, which is at present filled with their colonies.

The people of Africa are, as it were, buried in the midst of a great continent, destitute of gulfs and arms of the sea, to call forth their enterprise or their invention, or enrich them with the gains of commerce. This circumstance has powerfully contributed to repress the energies of the nations of that continent.

The nations who have peopled Europe, on the contrary, had to cross the Caucasus, the Alps, the Black Sea, the Baltic, the Grecian Archipelago, the Adriatic, or the Mediterranean. Obstacles so formidable retarded them at first in their progress; but at the same

his letters at length, and tell the world all he knew about him: for then he would have appeared to the world as he was, and his writings would have been left to that class to which their author belonged.

time, they served to develop and fortify that character of activity and courage which is common to the European nations. The descendants of Canaan, the Phenicians, gradually lost the empire of the sea; Athens rivalled Tyre; a Grecian city ruled over conquered Egypt; Carthage submitted to Rome; and Europe seized the sceptre of the world. At this first epoch, all civilization was collected around the Mediterranean; it was almost the only sea upon which there was any navigation. A second epoch commenced, as the march of civilization was still intimately connected with the progress of navigation. The compass of Columbus appeared. A new world saw European vessels land on its shores. A new Europe has arisen, and continues to advance with giant steps in the career of improvement. The Atlantic Ocean has become what the Mediterranean was before, the great highway and thoroughfare of civilized nations.

But the march of civilization is far from being terminated; the wonders we have witnessed may still be surpassed. The Europeans have not confined themselves to the shores of that Atlantic Ocean, which, immense as it appeared to the Phenician and Greek navigators, is only a narrow sea, compared to that great ocean, which, under the name of the Pacific and the Southern, extends from pole to pole. American ships, by hundreds, already plough the whole of this aquatic hemisphere;—already British colonists have begun to settle Australia, which may be termed a continent, besides some of the large islands adjacent: and ere many ages pass away, these countries will exhibit the cultivated field, the crowded city, the hall of science, and the temple of worship of the true God. Then those wide-extended lands, whose plains and hills now produce only aromatic herbs, will produce the staff of life; bays now shadowed by a forest of growing trees, will display a forest of masts; gold, and more valuable iron, will be extracted from the bowels of mountains as yet untouched by the miner; coal will be dug up to move ships and machinery; coral and pearls will be dragged from the bottom of the sea, to adorn the new capitals; and the Great Ocean will then be the great highway of the nations, whose ships shall hail each other in peace, and advance to bloody fray no more; for the everlasting Gospel, diffused throughout the world, and rooted in the hearts of all, will ensure universal, never-ending peace, and national jealousies will forever cease.

§ XV.—Course of Civilization throughout the World.

The banks of the Nile and the Euphrates witnessed the first civilized communities of whom we have any account. From the former river, a stream of population seems to have carried some of the arts

along with them to the eastern borders of Asia. But here we observe no very marked progress. Very different was the course of that which spread towards the west. Greece received her earliest knowledge from Egypt and Phenicia, and carried many branches of the arts to the utmost attainable limits, while she vastly increased the amount of scientific knowledge, and left compositions which please, elevate, and instruct to this day. Rome received the intellectual treasures of Greece, added to the store, exhibited a new phase of law, government and public policy, and spread civilization to the Atlantic Ocean, along which it spread, from Gibraltar to the Norwegian snows. In the mean time immense changes had taken place, to alter the whole face of civilized society. A new religion had appeared, differing in many of its doctrines and precepts from all those which had previously prevailed among the nations. It made new revelations of the Creator, of man's nature, duties, and destination, and laid down new rules for his conduct. The overthrow of the Roman Empire, soon after this religion had spread over southern Europe, apparently threw everything into confusion; the once vigorous sway of Rome was prostrated in the dust; and the world saw the fall of the last universal empire. Rude, illiterate warriors from the north and east seized the western dominions of Rome, destroyed many of the monuments of antiquity, and apparently effaced the very footsteps of civilization. Here they plunder and destroy churches, and murder the ministers of religion; there, when overcome by the professors of the new faith, they submit to the initiatory rite of baptism, to save their lives. Who would expect that from such beginnings should arise a civilization more expansive, more thorough, and above all, more benign than that of Thebes, of Athens, or of Rome? Yet, such was the result,—and the descendants of the very men who nicknamed their leader for condemning their horrid and inhuman barbarities,* were to contribute their share:—such is the power of the Gospel of Christ. Those rude warriors passed away, and with them the darkest part of their character, while the bright was to be more fully developed in their descendants. Numerous causes, which we cannot stop to enumerate, had excited some degree of inquiry, enterprise, and mental culture in Europe, when the discovery of a new continent, at the end of the 15th century, aroused the already wakening mind of Europe from the slumber of ages, and set in motion agencies, of whose results we yet see only a small part.

* An army of Normans called a distinguished general in contempt *Olver Barnacarl* (children's old man,) because he expressed his disapprobation of their custom of amusing themselves, after plundering and burning a city, by tossing captive little children in the air, and catching them on the points of their spears as they fell. Such were the men whose descendants originate *benevolent associations.*

The great questions touching the relation of man to God, to his fellow-creatures, and to the universe, and domestic, social, and political order, which had all been solved after a sort, at the beginning of the halt, were brought again into discussion; and then civilization, taking up its line of march, has moved onward, towards the West, to give these discussions a new solution, in a new sphere of action; and the whole civilized world awaits the issue with eager interest. The Christian feels no uneasiness, but goes straight on in the course of duty; for he knows the result, though not the exact time of its accomplishment.

The eastern civilization has its centre in China, and its outposts are Japan. It embraces its hundreds of millions of men, and has moved in a direction contrary to that of Europe, from west to east. Its locomotive powers are slight, and it seems to have been nearly stationary for several centuries. We might compare the respective speed of these two civilizations, to the two great revolutions of the globe, viz., the annual revolution in its orbit, and that which gives rise to the precession of the equinoxes. The eastern civilization is less active, and less easily set in motion than the western. But we must do it the justice to confess, that to it belongs the honor of several capital inventions and discoveries, such as the mariner's compass, printing, and gunpowder,* on which the Europeans pride themselves; and we must also acknowledge, that the eastern civilization has solved the mighty problem of keeping under one law, for an indefinite number of ages, a population greater than that of all Europe. The Roman empire, whose population was less than that of China, stood whole only three hundred years. The spiritual authority of the Pope, which extended over a still smaller surface of territory, was absolutely acknowledged at all, only from Charlemagne to Luther, and rejected by many even before Luther's time.

The two civilizations, thus extended to the extremities of the old continent, were separated by an immense space, before the western had fixed itself in America. Now more than half the intervening distance is passed: Mexico and South America are covered with offsets from the latter, on the side which looks towards Asia, as well as on that which fronts Europe. The more energetic race of the United States have extended themselves from sea to sea, and now meet the sons of Han on each shore of the great ocean. From this point of view it is clear that America, placed between the two civilizations, is reserved for high destinies; and that the progress of the New World is a matter of the deepest interest to all the human race.

Since the age of Louis the Fourteenth, the European merchants, who are the pioneers of state policy, strove with a constantly increasing

* These were all brought from China to Europe in the middle ages. Europeans, however, greatly improved on the Chinese inventions.

ardor, to open closer relations with China, because they have felt the importance of a regular system of exchanges between Europe and a mass of two hundred and fifty millions of producers and consumers. The emancipation of the United States from British thraldom, and the abolition of the monopoly of the East India Company, gave to the efforts of commerce an irresistible force; and, notwithstanding the palpable injustice of their course in the late war with China, the British were nowhere loudly censured by public opinion, because the nations were aware of the immense advantages which would accrue to China itself, and the world at large, from throwing open that vast empire, whose territories include one third of the Asiatic continent, to pacific and general intercourse with Christian and more civilized states. The cause of the British was unjust, because they were forcing their destroying drug upon an unwilling government. Yet the real conduct and motives of the Chinese government and its functionaries, were mean and contemptible. The mandarins had been in the habit of conniving regularly at the introduction of opium, up to the time of the rupture with the British, although there were ever so many state proclamations against its introduction, the only condition being a heavy secret payment. When the proclamation appeared which led to the seizure of the opium at Canton, the British thought it was merely designed to extort heavier payments. The Chinese government was now serious, simply because they found that the immense quantity of opium introduced, turned the balance of trade against their country; and instead of receiving specie, they now had to pay a large sum to "the red-bristled barbarians,"—as they then termed the British,—to cover their deficiency in exported goods. The lofty allusions to public health and morals were nothing more than a mask to cover the real motive, which is seldom avowed by absolute governments. The result of the war will be highly beneficial to China, because the missionary can now enter their country to give them a knowledge of the only true religion; and the humiliating knowledge of their own inferiority (which was forced upon them by the ease with which a handful of British completely prostrated the whole military strength of their vast empire, and compelled them to pay in full for the expense of defeating them,) must make them more willing to learn their sciences and arts. Before this power, the laws which closed up the Celestial Empire, gave way. The unimpeded introduction of opium will produce more evil at first than existed under the old system: but it will tend to open the eyes of the Chinese more effectually to the pernicious consequences which follow its use; and thus lead more quickly to its general abandonment.

Subsequent to the opening of China, the Turks have been induced to lay aside their intolerant bigotry; and thus the middle of

the 19th century has witnessed the removal of the two great barriers which excluded from Asia the knowledge and civilization of the west. The exclusive policy of Japan, also, must soon be classed with the things that were. The human race has come into possession of new means of communication, which shorten distance in an unexpected degree. The two civilizations are already commingling: a powerful stimulus is given to the oriental; and we already see the dawn of the day when the whole race of Adam will associate as one family, and with more friendly feelings than when Cain slew his brother.

Before the days of Christopher Columbus and Vasco di Gama, Europe had had communications with China, through the medium of the Arabs, independent of the caravans which traversed central Asia. The Arabs, conquerors and missionaries, placed between the two civilizations, formed a means of communication between the two. To the East, they were the messengers of the West, and to the West, the couriers and factors of the East. Unhappily, since the western civilization has shone with the greatest brilliancy in Europe, Arabia has thrown out but feeble gleams of light. While Europe and her colonies have acquired irresistible energy and activity, the Arabians—debased by the religion of the false prophet* —have fallen into a deep lethargy; in that quarter, therefore, the intercourse, which was never speedy nor complete, has almost ceased. But if, as some suppose, the Arab race is about to rouse itself from this long stupor, at the voice of Christian truth, the West will have a powerful ally in its efforts to transmit to Asia the means of obtaining a higher standing among the nations; and this illustrious and wide-spread race will thus powerfully contribute to the union of the two civilizations, through the ancient channel of communication, while the steamboat communication through the Red Sea and the Mediterranean opens a shorter means of communication between the furthest east and the extreme west.

The nations whom we were accustomed to call Oriental, but who are only inhabitants of the nearest east, have ceased to be formidable adversaries to Europe; they delivered up their swords at Gizeh, Navarino, and Adrianople. The colonization of America is now, at length, completed, from Hudson's Bay to Cape Horn; Europe moves towards the east, as well as towards the west. The Isthmus of Suez, and the Isthmus of Panama, are becoming the routes of western civilization to the great East. Britain chiefly traverses the one and her American descendants the other: and these two nations

* Wherever Mohammedanism prevailed, the effects have been the same,—first, great activity and vigor, followed by a total prostration, as the consummation of a steady decline.

completely overshadow all others in the career of advancing and diffusing civilization.

ADDENDUM TO SECTION III.

[The following remarks on Hassell's Ethnographic Table were accidentally omitted in the proper place.]

The preceding table is defective, in several respects. Some classes are over-estimated, as the Japanese; and others are under-estimated, as the Germanic nations and their descendants. Some races, again, are classed together which have no affinity, as the Basques with the Cymric and Gaelic tribes. The various distinctions between the Hottentots, Papuans, and Alforians, are also overlooked. Notwithstanding these defects, however, the table appears to have been compiled with care; and it will give the reader a tolerably accurate notion of the comparative numbers of the various races of mankind. We are not at present in possession of data that would enable us to give a table which could be depended on for perfect accuracy; and therefore, we have given Hassell's nearly as we found it. The principal change which we have made, consists in classing the Turks and western Tartars with the Mongolian race, to which they properly belong. We have preferred this course to indulging in the day-dreams which are still so freely and unhesitatingly laid before the public.*

* Of these we have a good instance in Kombst's Ethnographic map of Britain, published in Johnston's Physical Atlas, where we are gravely informed there are in Britain 16 millions of unmixed descent, although it is actually a moral impossibility that there can be one tenth of that number; and in all probability there is not a solitary individual who is not more or less of mixed descent.

PART II.

RELIGIONS.

§ I.—General Survey.

The inhabitants of the earth may be divided into three classes, in a religious point of view, viz.:—Christian, Mohammedan, and Pagan.

The first, in point of numbers, considerably exceeds the second, and still falls far short of the third; but the nations which profess Christianity have acquired so great an ascendency in arts, social improvement, and political power, while their colonies have filled, and are multiplying over all the savage and unoccupied portions of the globe so fast, that this faith is now more widely diffused than any other.

The Mohammedan nations, though far inferior in numbers to the Christians, occupy a large proportion of the most fertile regions of the globe, but are sunk in slavery and degradation, so much so, that their sway is not likely to endure above a century or two longer.

Of the Pagan religions, the most numerous, and the only civilized possessors, are those attached to the kindred creeds of Brahma, and Buddah, the former of which is established over the greatest part of Hindoostan; the other of China, and other continental kingdoms and insular territories of eastern Asia. From their peculiar habits, and the immutable nature of their institutions, they are likely to adhere to these systems with greater tenacity than the votaries of superstition in Africa, the South Sea, and other quarters, where the train of belief and observance, however fantastic, is of a slighter texture.

The following table shows the estimates of Hassell and Malte Brun, of the various religions, omitting all numbers below thousands:—

I. HASSELL'S ENUMERATION.

Pagans,	561,820,000
Christians,	252,565,000
Mohammedans,	120,105,000
Jews,	3,930,000
Total of the globe,	938,420,000

Roman Catholics,	134,732,000
Greek Church,	56,011,000
Protestants,	55,791,000
Monophysites,	3,865,000
Armenians,	1,799,000
Nestorians,	367,000
Total of Christians,	252,565,000
Lutherans,	24,264,000
Presbyterians and Congregationalists,	12,760,000
Episcopalians,	14,905,000
Methodists, Baptists, &c.,	3,862,000
Total of Protestants,*	55,791,000

II. MALTE BRUN'S ENUMERATION.

European Catholics,	88,000,000	116,000,000
Catholics out of Europe,	28,000,000	
Greek Church,		70,000,000
Protestant Churches,		42,000,000
Total of Christians,		228,000,000
Jews,		5,000,000
Mohammedans,		110,000,000
Brahmins,		60,000,000
Shamanists, or Lamaïtes,		60,000,000
Buddhists, and kindred creeds,		150,000,000
Fetichists, and various others,		100,000,000
Total of Pagans,		310,000,000

§ II.—PROTESTANT CHRISTIANS.

Lutheranism, or the Evangelical Church, is supported by the state in Prussia, Saxony, Hanover, Denmark, Norway, Sweden, and Livonia.

Calvinism, or the Reformed Church, is the most prevalent in Switzerland, in some countries of Germany, and in Holland. It is also that of the established church in Scotland, and most of the dissenters in that country belong to the same persuasion. We may identify with the Reformed Church, the Congregationalists, who are numerous in Britain and the United States.

* All the Protestant denominations are under-estimated, and the fourth class exceedingly so.

The English, or Anglican Episcopal Church, is the established religion of England; and in Ireland, although the faith of the minority, it is upheld by the strong hand of power.

The preceding tables give no distinct account of many Protestant denominations. Of the Unitarians, or Antitrinitarians, most of those who have separated from other denominations are found in the United States and in Britain; but many holding their sentiments are found in other communions.

The Arminians, or Remonstrants, were originally a party which sprung up in Holland, and who differed from the Calvinists in the opinions which they held concerning the doctrines commonly called the Five Points. Their opinions, with various modifications, are now held by the majority of Episcopalians, and by many among the other Protestant denominations.

The Antipædobaptists, or as they are commonly termed, the Baptists, are a numerous party in the United States, and have many congregations in Britain. There are several subdivisions of them. The United Brethren, or Moravians, are Arminians in creed, and Episcopal in church government. They are found chiefly in northern Germany, and in the United States. They were among the first Protestants who carried the blessings of religion and the useful arts into heathen lands. The Friends, or Quakers, the Shakers, Dunkers, and Swedenborgians, are found chiefly in England and the United States. The Swedenborgians were followers of Baron Swedenborg, a Swedish nobleman. The Methodists, who originally were seceders from the English Church, are very numerous in America and England. Their creed is exclusively Arminian, with the exception of the Whitefield Methodists, who are Calvinists. These are found chiefly in England. The amount of good they effect in new countries is immense—breaking down the rough places, and hewing out a path of holiness and light, and acting as pioneers to all other sects.

The following table, compiled from the most recent returns and estimates, exhibits the number of churches, ministers, and communicants belonging to every denomination in this country, excepting a few of the smallest. The numbers in round thousands are only approximate estimates.

RELIGIOUS DENOMINATIONS OF THE UNITED STATES.

Denomination.	Churches.	Ministers.	Communicants.
Roman Catholics, ...	966	1,026	1,231,300*
Methodists,—various classes, . . .	—	6,707	1,215,069
Baptists, do.	14,111	8,425	1,007,653

* The Roman Catholic communicants are disproportionately large—the *whole number* of their adherents being much smaller than that of the Metho-

Denomination.	Churches.	Ministers.	Communicants.
Presbyterians and Reformed,*	6,210	4,944	594,073
Universalists, ...	1,500	1,500	325,000
Congregationalists (Evangelical), . .	1,971	1,687	197,196
Lutherans, ...	1,604	663	163,000
Protestant Episcopalians, ...	1,232	1,497	67,550
United Brethren, ...	1,822	524	67,000
Unitarians (Congregational and Baptist)†.	907	748	33,000
Swedenborgians, ...	42	30	5,000

§ III.—Greek and Roman Catholics.

The Greek, or Eastern Church, which was most orthodox in the fifth and sixth centuries, is the established religion of Greece and Russia; and it is tolerated in Turkey, and in the Austrian dominions. Among its kindred branches, are the Nestorians, in Asiatic Turkey, who, at one time, were very numerous in Tartary, Mongolia, and even in China; and the Monophysites, who comprehend the Copts in Egypt; the Abyssinians, the Armenians, and the Jacobites of Syria and Mesopotamia. Some of these have recently joined the Roman Catholic Church: but their number is not considerable.

The Roman, or Western Church, comprehends within its pale the greatest part of France, Belgium, Italy, Spain, Portugal, Austria, Poland, southern Germany, the numerous Spanish and Portuguese Colonies in America, Africa, and Asia; three fourths of the population of Ireland, one half that of Switzerland, and one third that of Holland, besides many adherents in Britain. The Pope is considered the spiritual head. The Gallician, or French Church, was formerly distinguished by peculiar tenets and privileges, which opposed an invincible barrier to the usurpations of the Pope. But this distinction is no longer maintained.

§ IV.—Mohammedanism and Judaism.

Christianity has seen many enemies arise, but none greater than Mohammedanism, or Islam, which is a confused mixture of Judaism,

dists and Baptists—because most of those belonging to their denomination communicate. The terms of communion vary so much among the other denominations that the number of communicants is not an exact criterion of the total number of a denomination.

* The Dutch Reformed and the German Reformed. Both of these have the same creed, and essentially the same form of church government as the Presbyterians.

† We give these by themselves, as their creeds are essentially different from those of the other Congregationalists and Baptists, though they have the same form of church polity.

Paganism, and Christianity. Some portions of the Koran are said to have been stolen from the Bible by its subtle writer.

The Mohammedan creed prevails in the greater part of western Asia, in most of Africa north of the equator, and in European Turkey. It is also tolerated in Russia. Mohammedanism comprehends several sects. The Sunnites, and the Shiites, or Separatists, are the principal. The Sunnites, though divided, with regard to discipline, into four parties, agree in reckoning the book of Traditions, or the Sunna, in the number of their sacred writings, and in considering Omar and his successors as the legitimate Caliphs. The Sunnites give the name of Shiites, (i. e., Separatists,) to all who differ from them. They reckon six classes, each split into twelve subdivisions, which makes seventy-two heretical sects; for the Turks have thought, like Bossuet, that a multiplicity of sects furnishes a plausible objection to their doctrines. There is, however, but one considerable party among the Shiites, that of the followers of Ali, who reject the Sunna. This creed is prevalent in Persia. The other Mohammedans—the Turks, Arabs, Tartars, and Mohammedan Hindoos and Malays—belong to the Sunnites. This sect numbers about one hundred millions, and the Shiites about fifteen millions. The Wahabees, Sunnite reformers in Arabia, embrace about five millions.

Judaism, which long preserved a knowledge of the true God amid heathen darkness, is now divided into two principal sects—that of the Karaïtes, who acknowledge as Divine only the books of the Old Testament—and that of the Rabbinists, or Pharisees, who attribute an authority almost divine, to the collection of traditions and explanations known by the name of Talmud. The latter are by far the most numerous. The Karaïtes are noted for general integrity of conduct, and being often devoted to agricultural pursuits.

The Jews are found scattered over the whole world; but they are most numerous in the Turkish and Austrian dominions, and in Russia and Poland. There are also many in Germany, France, and Holland; and they are increasing very rapidly in the United States, which is one of the very few countries where they possess all the rights of citizens. In some parts of Europe, they are prohibited by law from settling in the country; and in most other parts, they are laid under many disabilities. Many of the Jews of the present day are infidels, having no belief in any revelation; but these opinions are confined chiefly to German Jews.

To Judaism we may refer the Samaritans, who are still found in Egypt and Palestine, chiefly in and around Nablous, the ancient Shechem. They expect the Messiah, and observe the Mosaic law, like the Jews; but they receive no part of the Bible except the five books of Moses, of which they preserve a celebrated and very ancient version, written in characters much older than the common Hebrew

letters. Their views regarding the Messiah are more correct than those of the Rabbinists, who generally expect only a temporal deliverer and sovereign. The origin and early history of the Samaritans can be learned from the Old Testament; for they are the same people that are spoken of both in the Old and the New Testament.

The Jewish Scriptures and Jewish polity, were designed only to pave the way for the introduction of Christianity, which sprung up in the bosom of Judaism, and now sheds its benignant and liberal influence over the most civilized countries, and in all quarters of the globe.

§ V.—Missions.

The Roman Catholics have many missionary establishments among the heathen: but they are less flourishing than those of the Protestants. The following table contains the names of the principal Protestant Missionary Associations in the world, and the countries where they sustain missions.

I. MISSIONARY ASSOCIATIONS.

American Board of Foreign Missions; Presbyterian Board of Missions; American Baptist Missionary Society; American Methodist Missionary Society; American Home Missionary Society; Protestant Episcopal Missionary Society; American and Foreign Christian Union; United Brethren; (English) Society for Propagating the Gospel in Foreign Parts; Society for Promoting Christian Knowledge (London); London Missionary Society; Church (Anglican) Missionary Society; Wesleyan Methodist Missionary Society; Baptist (English) Missionary Society; London Society for Promoting Christianity among the Jews; Colonial Missionary Society; General Baptists' Missionary Society; Scotch Church Missionary Society; Free Scotch Church Missionary Society; French Protestant Missionary Society; German Missionary Society; Rhenish Missionary Society; Netherlands Missionary Society.

II. COUNTRIES CONTAINING MISSIONARY STATIONS, AND ASSOCIATIONS BY WHOM SUSTAINED.

Countries.	By whom sustained.
Greenland and Labrador, .	Moravians, or United Brethren.
Upper Canada, ...	Moravians and English Episcopalians, Wesleyans.
Chippeway and Sioux Ind.,	Amer. Board of Foreign Missions.
Cherokees and Choctaw Ind.,	American Board and American Baptists.

Countries.	By whom sustained.
West Indies, ...	Moravians, English Baptists, Wesleyan Methodists, English and Scotch Churches.
Guiana, ...	Moravian and Baptist Missions.
Turkey, ...	American Board, English and Scotch Church.
Greece, ...	do. do.
Western Asia and Persia, .	American Board.
Siberia, ...	London Missionary Society.
Western Africa, ...	English Church Miss. Soc.; United States Episcopal Missionary Society; Wesleyan Methodist; German Missionary Society; American Baptist and Methodist Missionary Societies; American Board.
Southern Africa, ...	London Missionary Society; American Board; Scotch, Moravian, Wesleyan, French, and Rhenish Missionaries.
Madagascar, ...	London Missionary Society.
North Hindostan, ...	English and Scotch Churches; London Missionary Society; Baptists and Methodists.
South Hindostan, ...	English Episcopalians, Methodist Society, and American Board.
West Hindostan, ...	English and Scotch Churches, and American Board.
Ceylon, ...	English Episcopalians, Methodists, Baptists, and American Board.
Eastern India, ...	American Baptists; London Missionary Society; English Church Missionary Society.
China, ...	American Board; United States Episcopal Missionary Society.
Australia and New Zealand,	English Church Missionary Society; Wesleyan Missionary Society.
Malaysia, ...	American Board and Dutch Missionary Society, and German Missionaries.
Sandwich Islands, . . .	American Board.
Society and Georgian Isles,	London Missionary Society.
Friendly, Navigators', and Fegee Islands, ...	Wesleyan Missionary Society.

§ VI.—Polytheism.

The name of *polytheism*, (worship of many gods,) is given to every system of religion which admits the existence of several gods. One of the grossest is fetichism, or the worship of fetiches. By *fetich*, (a word which comes from the Portuguese,) is understood all sorts of animated or inanimate substances which the priests of this religion hold out to the savages as beings who are endowed with some divine and magical power. This absurd religion prevails among the ignorant nations of Soudan, and Guinea, and among a variety of other savages. The ox Apis, and the dog Anubis, were the great fetiches of the ancient Egyptians; but they had many others, including the ichneumon, cat, leek, onion, etc. The worship of fetiches is only one of many customs which connect the modern Africans with the ancient Egyptians. The black stone worshipped at Mecca before Mohammed, was undoubtedly a fetich. Ridiculous and debasing as the worship of such deities certainly is, the worship of such horrid characters as the Moloch of the Canaanites, Phenicians, and Carthaginians, and the Jupiter of the Greeks and Romans, was equally absurd, and still more pernicious in its effects.

Sabeism, or the worship of the heavenly bodies—the sun, moon, and stars—is essentially fetichism, but a less degrading form of it. This very ancient system spread over the whole extent of the globe; and was blended with all the other systems of superstition. But it no longer exists entirely pure, except among some insulated tribes. It has the name from the Sabeans or Sabians, an ancient people of Arabia. The worship of *Baal* and *Ashtaroth*, so often mentioned in the Bible, was of this kind, Baal being the sun, and Ashtaroth the moon. The Greeks called the former *Apollo* and *Phœbus*, and the latter *Artemis*, *Phœbe*, and *Hecate*.* The worship of Baal passed into Gaul by means of the Carthaginians, whence it passed into Britain and Ireland. In all these countries, its ministers were termed *druids;* and the great festival of Beal-tain, (Baal's fire,) is still observed in some parts of the Scottish highlands, though the system of Druidism fell into general disuse in the beginning of the second century, when Trenmor, the first Gaelic king of the country, suppressed the druids. The Romans had previously abolished the order in south Britain and in Gaul. The human sacrifices common among the druids demanded such a step.

All the polytheism of the world arose from two sources—the deification of men, and the worship of external objects. In the case of several deities, the two seem to have been blended; a real human character was taken as the representative of some natural object, or

* The *Diana* of the Romans.

power, and endowed with corresponding fictitious attributes. Thus, the *Hephaistos* of the Greeks, and the *Vulcanus* of the Romans, was probably the *Tubal-Cain* mentioned in the fourth chapter of Genesis as "an instructor of every artificer in brass and iron"—in other words, the inventor of the arts of preparing and working metals. Traditional accounts of him were preserved; and he was taken as the representative of the principle of fire or heat, on which the metallurgic arts depend. The very name *Vul-can* is not improbably an abridgment of *Tu-bal-cain*. Of external objects, the sun would attract pre-eminent attention: and when mankind abandoned themselves chiefly to the gratification of their senses, and paid little serious regard to the real cause of the phenomena of nature, the invisible God was forgotten; and it followed almost as a matter of course that the all-resplendent sun, on whose movements depend day and night, summer and winter, should be viewed as the great ruler of nature. Hence, the worship of the sun has been so general among pagan nations, from the earliest times. It has been found throughout the world, all round from Ireland to Peru, where it constituted the religion of the Incas. It was also the religion of the Aztecs, in Mexico, where 20,000 human victims were offered to the sun every year.

The respect due to ancestors and to public benefactors was the other most prolific source of polytheism; and the hundreds of millions of China, at this day, worship no other god with any degree of fervor except their ancestors.

It is remarkable that the Mongol race, and the American Indians, preserved the knowledge of the true God better than any other people, except the Hebrews, whose worship was kept pure by peculiar dispensations. This fixity of character in the Mongol and American races—which also exhibits itself in many other things—would lead to the inference that they are of the race of Shem—whose known descendants exhibit an incapacity for speculation or invention, and an attachment to one unerring course of conduct, and to ancient belief and usages—rather than to the inventive, speculative, novelty-loving sons of Japhet, who introduce a new mode of dress every month, while the sons of Ishmael dress and live at this day precisely as did their ancestor nearly 4,000 years ago. How far the Mongol languages confirm or refute such an inference, we cannot say: but we believe a comparison of these and of other traits would settle the question.

Polytheism seems to have been often little influenced by philosophical speculation. It was much older in point of time, and in many cases, too firmly rooted in the customs and affections of its votaries to be influenced by philosophy, when it appeared. The lofty and beautiful views of Socrates had no influence even on the

cultivated Athenians, who listened with pleasure to the scurrility with which Aristophanes attacked the philosopher, the greatest of the Grecian race. The worship of Bacchus and Venus was much more to their taste than one less sensual and more rational. Here lies the secret of the strength of polytheism: it was, in fact, made by mankind according to the desires of their own darkened and debased minds. Some would have us think, indeed, that the ancients generally attached an allegorical meaning to their worship; but of this there is not a shadow of proof, so far as the great majority are concerned, while there are innumerable proofs of the contrary. We need not wonder that Greeks, brought up in heathen darkness, should approve of their own superstitions and abominations, when Gibbon, the historian, a man brought up in Christian society, could deliberately and publicly call the disgusting compound of puerility, cruelty, and gross sensuality, which constituted their religion, "the elegant mythology of the Greeks," and this while he thoroughly knew its real character, which school-boys generally do not.

The worship of national heroes modified the polytheism of the Greeks and Romans. Veneration for the dead—a natural sentiment—mingled with all religions; and of some, it seems to have formed the chief part, as was the case with the Caledonians, in the times of Ossian. The Syrians, the Chaldeans, and the Phenicians, appear to have made the heavenly bodies the objects of their especial worship.

In the religion of the Brahmins, *Brahm*, or the supreme being, is supposed to have created three great deities, *Brahma*, the creator of the universe, *Vishnu*, the preserver, and *Sheeva*, the destroyer. This is, apparently, a speculative system. As Brahm and Brahma are not now supposed to interfere with human affairs, little attention is paid to them. Vishnu is said to have become incarnate nine times. The tenth incarnation is yet to occur, when he will appear on a white horse, with a flaming sword, to take vengeance on the wicked. The celebrated Juggernaut is one of the supposed incarnations of Vishnu. As he acts only occasionally, he is not so generally worshipped by many of the Hindoos, as Sheeva, the destroyer, terror being a greater element in their worship than affection. The ancient religion of the whole Indo-Atlantic race appears to have been essentially the same. There was an original creator, who, however, seemed to interfere little with the universe, which was chiefly influenced by the conflicting operations of the good and the evil principle. The *Ormuzd*, or *Oromastes*, of the Magians, and the *Biel-bog*, or white god, of the Sarmatians, or Slavons, were only modifications of Vishnu; and the *Ahriman* of the former, and *Czerno-bog* of the latter, corresponded to Sheeva, or the Devil.

Shamanism, the religion of the Thibetans, some of the Chinese and the heathen Tartars, appears to have much in common with the Brah-

minical system; but we have little reliable information concerning it. Several of the Tartars, however, undoubtedly pay homage chiefly to the evil deity, alleging as a reason, that the good does not require to be propitiated. Many of the Indo-Atlantic race, in the course of time, adopted the religion of other nations, with whom they associated. Thus, the Greeks adopted much from the Phenicians and Egyptians, from whom, indeed, the Ionic Greeks seem to have been partly descended. The Greek religion was afterwards largely adopted by the Romans, who had previously borrowed much from the Etruscans. The Celts and Belgae adopted the Phenician religion from the Carthaginians, and introduced it into the British Isles.

Buddhism is only a modification of Brahminism, which prevails in southern and further India, China, and Japan. But it rejects castes, and many of the cruel practices of the Brahmins. It maintains, in common with them, that the soul is an emanation from the deity, and will ultimately return to its origin, and cease to exist as a distinct consciousness: but no soul will attain this supreme felicity of annihilation, till it has expiated any guilt it may have contracted, by inhabiting the body of some future person or animal, where it may suffer for its sins in the former state. Hence their aversion to kill any animal. A Hindoo would abhor killing a lame duck: for it might be the tabernacle of the soul of his grandmother. So it is affectionately sent to an hospital. Many of the views of the priests and learned among them, however, seem to have comparatively little influence on the masses of the people, whose worship is chiefly directed to inferior deities, whom they believe to influence their present circumstances.

The polytheism of the more remote and less enlightened pagans, such as many of the Malaysians and Polynesians, seems to be a kind of hero-worship, which is generally as bloody and revolting as that of Moloch, although many of the usages of the Brahmins are equally abominable. True philanthropy rejoices at the dawn of a better day, when polytheism will be numbered with the things that were, and the nations will offer a pure and heart-felt homage to Jehovah, and rejoice in the light of His countenance.

PART III.

GOVERNMENT.

---

§ I.—Definitions.

Government is the union of physical force, established to control civil society. The person or persons who exercise this force are called the *supreme power*. This may be divided into different branches, as the *proposing*, the *deliberating*, the *decreeing*, and the *executive* power, which may be divided into the *administrative*, the *judicial* and the *military*. These divisions are, in a great measure, arbitrary, and varied by the circumstances and characters of different nations. The manner in which the supreme power is organized, subdivided, and concentrated, is called the *form of government*.

Forms of society are innumerable; but we shall point out those most generally known, by advancing from the state of the greatest physical dissemination of powers, to those of greatest concentration.

§ II.—Description of the Various Forms of Government.

Pure democracy exists in that state in which the supreme power is vested in, and immediately exercised by the majority of the nation: this form of government differs from the state of primitive civil society, in which all equally rule.

Modified democracy is a state in which the supreme power is exercised by a council immediately chosen by the people, revocable, and responsible to them.

A *representative* democracy, is that state in which the supreme power is exercised by magistrates, chosen from among the people whom they represent, but who, when chosen, are sovereign, and not responsible. This form is subdivided into a *pure representative* democracy, when the people themselves directly choose their representatives; and into a *representative electoral* democracy, when the people choose electoral bodies, who elect representatives.

Elective aristocracy is, when the people, either mediately, or intermediately, choose their magistrates, not indifferently from among

the citizens, but from a certain class, determined by law. [illegible] aristocracy is *free* when the people have retained the privilege [illegible] [illegible] that body a [illegible] [illegible] the supreme power in the hands of the [illegible] *Pure* [illegible] aristocracy is, when the [illegible] [illegible] hereditary representatives [illegible] gives and [illegible] without the concurrence of the people.

[illegible] form of government compounded of these which we [illegible] called an *aristo-democracy*. When the aristocratic party seems to predominate, we have a temperate aristocracy; when the democratic party prevail, we have a temperate democracy. Rome after the expulsion of the Tarquins, was an hereditary [illegible]*garchic aristocracy* which gradually changed into an aristo-demo*cracy composed of* all the other kinds. The patricians were a *hereditary aristocratic body*: the senate an elective aristocracy; while the assemblies of the people represented the democracy.

A *democratic monarchy* is a democracy in which the supreme *power* is partly *exercised by* an individual and partly by a democratic body. As the supreme power may be variously divided it is impossible to ascertain the number of the different kinds of democratical monarchies. It may be hereditary, when a nation has chosen a certain family, or elective, when, at each vacancy, a monarch is chosen. The right of election may be vested in the people, in an electoral body, or in a single elector. These variations are common to other kinds of monarchy. The legislative power may be divided between the commissioners of the people and the monarch, or it may belong to the former only. The judicial and military powers may be dependent upon the monarch, or upon the body of the nation. The democratic body itself, may be chosen without or with the concurrence of the monarch.

Aristocratic monarchy is a state in which the supreme power is jointly shared by the monarch and the aristocracy. This latter body may be a free, elective aristocracy, when an assembly of representatives, chosen by the people, form the council of the monarch, or an elective hereditary aristocracy, chosen by the people, or by the monarch, or by both conjointly; or, lastly, it may be a pure and perpetual aristocracy, independent alike of the people or of the sovereign. Such were the nobility in most of the European states before the present epoch.

The *aristo democratic* monarchy is a government composed of a monarch, of an aristocratic body, and a democratic body. By a *mixed government* is generally understood a monarchy of this description. The combinations of this form are so multiplied that it is impossible to class them.

A *pure* or *absolute monarchy* is a state in which the supreme

power is entirely confided to one individual, or in other words, a state in which the majority of the nation is represented by a single individual. Absolute monarchy differs from despotism, in this, that the monarch holds his power of the nation, either by expressed or tacit consent. The despot, on the contrary, pretends to hold his power from God, or rather from his own sword. The dictatorship in the Roman republic was a kind of absolute monarchy, elective and temporary.

The word *anarchy* literally means the absence of a government. Taking the word government in its true and literal signification, it is evident that anarchy may arise in two ways:—1st, from the non-existence of any supreme power in civil society; 2d, from the preponderance of unconstitutional power, exercised in an arbitrary manner and without the form of government. Anarchy may be modified in a thousand ways.

Ochlocracy, or *popular anarchy*, takes place when a mob or a multitude unlawfully usurps supreme power. According to this definition, even the majority, when they are not legally constituted sovereign, can exercise only anarchical power.

Oligarchy occurs when a small number of individuals or families exercise the supreme power, without having been chosen by the constitutional sovereign.

Demagogy is, when one or several individuals, without legal appointment, lead and manage the people at their will, actually exercising the power which they seem to leave in the hands of the multitude.

The word *tyrant* signified originally chief or monarch. Virgil employs it more than once in this honorable sense: but it was afterwards limited to denote him who, in a republic, had usurped the power of an absolute monarch. This is the ordinary sense of the term in the Greek and Roman authors. The moderns use the term to express violent and cruel abuses of authority, in all kinds of government.

Despotism has been confounded, sometimes with tyranny, sometimes with absolute monarchy. Despotism is absolute power, which is not derived from a lawful source, and which, consequently, admits of no limitations. The despot pretends to be the master of his subjects, and of his country, just as a private person is proprietor of his estate, or his cattle. Despotism is not necessarily tyrannical, or cruel, or violent; it is not absolutely incompatible with some administrative forms, and some institutions, which properly belong to regular states, or even republics.

It would be improper to class with these forms of government, or of anarchy, created by man, the singular state termed *Theocracy*. "It is," say the theologians, "a government instituted by God him-

self, in which the magistrates govern in the name of God." Such was the constitution of the Jewish people. With them, theocracy was first united with democracy, and then with monarchy. The Popes, in the dark and middle ages, attempted to establish a theocracy upon a great scale.

We have still to notice federal systems, which are the union of several independent states under a superior authority, chosen by themselves, and which are invested with powers more or less extensive, to maintain mutual order, and to furnish the means of defence against external enemies. We may term a confederation of which all the constituent members are on a footing of equality, a *democratic confederacy*. Such is that of the United States. There have been, however, confederations with a chief or presiding power. The Germanic Empire, which existed prior to the French revolution, was of this nature. Confederations sometimes have subjects in common. The Swiss had several districts in this manner.

§ III.—Origin of the Various Classes of Society.

In the most savage state, insulated man procures directly for himself the little which is necessary to supply his wants, or to gratify his wishes. As soon as families begin to draw near each other, they unite together for accomplishing their common labors; but when the number of families augments, the society becoming larger and more powerful, has recourse to the division of labor. The different products of each branch of industry are then reciprocally changed. These exchanges being not without inconvenience, means are sought out to give them facility and despatch. Some *measure*, to ascertain the comparative values of the different commodities, is adopted; either some article in general request, as corn, or cattle, or some reputed precious substance, such as gold and silver. This token of general barter or exchange, by which the value of any article is decided upon, constitutes *money*. The productions become *merchandise;* and instead of being *bartered*, they are *purchased*. Some sagacious observers now begin to perceive that gain is to be made by buying and selling. They become intermediate agents between the consumers of produce, and those who raise it, or work it: and here begins the first rude attempts at commerce. Ere long, the administration of the affairs, and the defence of the territories, of the state, become functions too laborious and too complicated to be gratuitously discharged: the functionaries, therefore, receive a salary, and instead of warriors, we have *soldiers*, who, when they are obtained from a foreign soil, and hired for a certain period, are called *mercenaries*, because they fight under foreign banners for money. At the same

time, every inch of ground would receive its master. Property of every kind, after having passed from one hand to another—chance favoring some individuals, and address serving others—would at last become fixed and settled. Those who had been unfortunate, or unskilful, finding the impossibility of producing anything on their own account, would let out their strength or dexterity to others.

From society, thus at last constituted, various classes originate.

§ IV.—Description of the Various Classes.

The *productive* class comprehends all those who draw from the earth, or from the other elements, any productions useful to society, such as cultivators of the soil, fishermen, miners, &c., &c. In civilized states, there exists one productive class of a peculiar kind. The *man of science*, who enlarges the empire of knowledge; and the *man of letters*, who purifies the taste, or refines the sentiments, or elevates the morals and manners of the age, equally contribute to the production of true national riches, of inestimable price, and perpetual duration; and the services of the *minister of religion*, which produce steady and industrious habits, are still more valuable.

The *operative* class consists of those who, by various processes, convert raw materials into artificial produce. When such processes eminently require genius and taste, they obtain the name of the *fine arts*. When they chiefly demand corporal strength and dexterity, they are called the *mechanic* arts. A *manufactory* is an establishment where an art is conducted on a large scale.

The *commercial* class is composed of *merchants*, properly so termed, who buy and sell, either on a small or large scale, the productions of nature and of art—of different kinds of *correspondents*, or *agents*, who facilitate the execution of purchases and sales—of *bankers*, and *brokers*, who confine their operations to the representative signs of merchandise, or bills and specie—and lastly, of [illegible], of *sailors*, and *carriers*, in so far as these are proprietors [illegible]r means of [illegible]veyance, and do not come to be ranked under the class of mercenaries.

We include in one class the *public functionaries* and officers of sea and land forces: as they are equally invested with a greater or less proportion of the force of the state, they are equally the agents of the supreme power.

The last class comprehends the *mercenaries* of every kind, who let out their labor to private persons, or chiefly to the community. It is composed of *laborers* and *domestics*. This last class is not so numerous, except in those states where luxury prevails.

The numerical proportion in which these classes are met with in a

state, is one of the most interesting questions of statistics. According to that proportion, we are to decide whether a nation is to be denominated agricultural, manufacturing, or commercial.

Classes have their foundation in the very nature of society itself; but *castes* and *orders* are created by laws and constitutions.

§ V.—Castes and Orders.

By the word caste is understood an hereditary class, exclusively assigned to one species of occupation. This system of division existed in Persia, Arabia Felix, and Egypt, and still exists in India. It is sometimes accounted for by referring to the original difference of the primitive tribes whose union formed the nation. But in several cases their origin seems to have been different. The caste of priests, and that of warriors, in Egypt, may have been two clans, somewhat organized and disciplined, which had reduced to a state of subjection several tribes of husbandmen and shepherds; the conqueror disdained to intermingle with the vanquished; and the laws afterwards sanctioned and perpetuated a system of separation which accident had originally established. Yet the perfect similarity of all the castes, and the unity observable throughout the nation, rather indicate a different origin.

The political orders of the states of Europe differ essentially from the castes, in this—that they have no occupation which is exclusively reserved for them; or if they have it, like the clergy, it is not hereditary.

In the middle ages, when the armies consisted of cavalry, the order of the nobility partook much of the nature of a caste.

The nobles are now merely an order of the state. The citizens, commonalty, or third order, and the peasants or laboring, agricultural class, form, in some states, orders recognized by the constitution. In Sweden the order of peasants possess much influence. The same was the case in Tyrol, before the French revolution. There are still, however, some countries, particularly Russia, where the husbandmen are subjected to the yoke of personal slavery, and form a real caste, condemned to a state of abject and perpetual degradation, to be sold like cattle with the land, and called *serfs*. They are said by the enlightened observers who have written concerning them, and witnessed their estate, to be but a remove higher than the brute creation, and governed by mere despotic force.

In despotic states, as in Turkey and China, there are no orders.

§ VI.—Density of Population.

The more a mass is concentrated, provided it has a free space sufficient to move in, the more energy it will acquire. A small populous country, therefore, is in proportion more powerful than a state of vast extent thinly peopled. A country is looked upon as populous when it contains 100 inhabitants to the square mile. England is peopled at the rate of 275, and Ireland has 260 to the square mile; but Scotland presents a less favorable proportion, being only about 90.

The Island of Malta is probably the most thickly peopled country in Europe. It had more than 600 souls to the square mile. But these are to be regarded only as rare local exceptions. It is common enough to find in European Russia, governments which have not more than 20, or even 10 inhabitants to each square mile. Belgium appears to be the most densely peopled country, of any extent, in the world: it has 364 inhabitants to the square mile.

The number of inhabitants is the foundation of every good system of finance; the more individuals a country contains, provided they have the means of subsistence, the greater progress will commerce and manufactures make, and, consequently, the greater the increase of the revenues. The number of inhabitants ought equally to determine the number of the troops. It is computed that the number of men capable of bearing arms, form about one-fourth part of the whole population.

The greatest effort, however, that a civilized state can make, in case of extreme necessity, is to arm the eighth part of its population. No example, even of this, has occurred in modern history.

§ VII.—National Debts.

The policy of contracting public debts is good or bad, according to circumstances. In general it is not desirable for a government, any more than for an individual, to be in debt: and yet some cases will justify a nation in drawing on its future resources. In pressing emergencies, taxation will not be adequate to the necessary expenditures; and, even if it were, it would be better perhaps to distribute a part of the burden through many successive years, by means of loans, because the suddenly levying of an immense tax might check the productive faculties of the people; and no wrong is done to posterity by this, where the object of the expenditure usually creates demand for an increased quantity of the products of the country, and thus stimulates industry. If, for example, the government has

a large army to maintain on its own territory, and the products of the country can supply it with arms, clothing, food, and all other articles, the army will be a stimulus to all kinds of industry concerned in affording its supplies. It may even happen that the very burden, or what seems to be one, will enable the people in general to be better clothed, fed, and lodged, since the means of a people, to produce the luxuries and comforts of life, depend very materially upon the facility and rapidity of exchanges of products of different sorts of labor, and great public expenditure often creates a market by increasing consumption, and thus stimulating industry. But, if the expenditure employs only the industry of a foreign country, or if an army is to be maintained abroad by the supply of articles wholly the product of foreign industry, there is no such compensation for the burden of the tax. Another advantage of public debts is their affording a means of investment, and thus encouraging the accumulation of property. Lands, houses, banks, canals, mines, and all other species of permanent property, afford a stimulus to industry and economy, as they offer the means of enjoying permanently the fruits of acquisitions: and public stocks have the same effect. Another effect of public debt is its attaching the public creditors to the government. But before their number can be sufficiently large to make their aid important to the government, the national debt must probably be increased by an amount that will render it burdensome. Among the disadvantages arising from the facility of contracting permanent public debts, one is the facility which it gives for the carrying on of wars and the indulging in other expenditures. And upon the whole, we may lay it down as a sound rule both of policy and morality, that distant generations should not be left to pay for the extravagance or the follies of the present.

The wars of Europe, since the public debt of Great Britain commenced under William III., are mainly attributable to this cause. Another disadvantage is the burdensome taxes to which the necessity of paying such a debt may subject the people. This is the operation of the national debt of Great Britain at the present time. It is impossible to prevent the burden of taxation from falling, directly or indirectly, in a very great degree, upon the laboring classes; and in Great Britain this has become so heavy to the mere laborer, who has no capital, that his wages will but just support, or will not support, himself and his family in the cheapest manner of living; and his life becomes one desperate struggle against want and starvation. At the present time, about three fifths of the whole annual revenue goes to pay the interest of the national debt. Another most disastrous result of a national debt is, that it forms a vortex for gathering the property of a nation into a few hands, adding to the incomes of those who have already more than enough, and rendering those

of the middle and lower classes permanently smaller. For a great part of the money raised off the mass of the nation, to pay the interest to the wealthy capitalist, never finds its way back, except in the shape of principal, lent to draw in still more interest.

§ VIII.—Origin of Standing Forces.

An armed force, naval and military, is unfortunately, but necessarily, an object of the first importance to every government. Savage tribes, and even half-civilized nations, are accustomed to march against their enemies, all the males fit to carry arms; and in some savage nations even part of the females accompany their husbands and brothers, not only to carry the provisions, but to fight, as is often the case with the Cumanche Indians. Fishing and hunting are occupations which savages carry along with them; and the women left at home may be sufficient for the employments of agriculture and the tending of cattle. But as soon as labor is multiplied, and consequently divided, that is, as soon as the agricultural, manufacturing, and commercial classes, have each a separate existence and place in society, it is impossible to arm and bring into the field the entire mass of a nation, without completely suspending the exercise of those trades and occupations on which its subsistence depends. It therefore becomes necessary to form a class exclusively devoted to the trade of war. Such was, in the middle ages, the design of the order of the nobility and of chivalry. But the invention of gunpowder and artillery, the introduction of a new system of fortification, aud the perfection to which tactics have been brought, have converted the former simple and almost mechanical art of war into a profound and extensive science, to the study of which many years must be devoted. This consideration, strengthened by motives of ambition and policy, gradually paved the way for the establishment of standing armies. The European powers have had, for more than a century, a certain number of troops in a state of perfect discipline and equipment, ready to march at one moment's warning. In supporting these troops, one third, and often one half, of the public revenue is often consumed.

§ IX.—Standing Army, or Land Force.

A standing army, or land force, is composed of four principal parts, with their divisions, viz.: the *infantry*, or combatants on foot; the *cavalry*, or combatants on horseback; the *artillery*, whose province it is to work those engines of destruction, on the skilful manage-

ment of which the success of the battle often depends; and the *engineers*, who conduct the defence and attack of fortified places.

Besides the army, every country where civilization prevails, is possessed of a collection of ships filled with armed men, and called a *navy*, or marine army, for the defence of their coasts and fortresses, and the attack of their enemies on the sea.

In the history of armies, we can distinguish those of three different periods: first, the *ancient* armies, which arrived at their perfection under the Romans; second, those of the *middle ages*, the offspring of the feudal system, ill-organized bodies, created only for a short time, and undoubtedly the worst that history makes known to us; third, *modern* armies, or such as have existed since the invention of gunpowder.

As long as personal strength, courage, and dexterity decided the fate of a battle, war had great charms for characters in high station. At that period, science had not become incorporated with the very life-blood of society; and the want of intellectual occupation contributed its share in making war a favorite pursuit with the higher classes. They fought mailed in thick armor from head to foot, bearing heavy shields or bucklers on their left arm, to ward off the blows of their antagonists. They were equipped and maintained at their own expense, and were accompanied by armor bearers to take care of this appurtenance. Under such circumstances, the art of war could never attain to perfection of a high degree, nor could the organization of an army be very complete.

The *tournaments*, or *tilting matches* of the middle ages, which used to be attended by the flower of chivalry, were established by certain monarchs for the purpose of keeping alive the military prowess of their nobles during peace, and exercise their skill by a species of military game, which, while it served to amuse the court, was supposed to be valuable in its influence.

It was not till the wars between Francis I., and Charles V., that the great importance of a regular infantry could be seen, and the Swiss, then the best foot soldiers in Europe, often determined the battle. The introduction of fire-arms had destroyed the ambition of the nobles for distinguishing themselves, for war was soon reduced to a system; the estimation of infantry constantly increased; volunteers became more rare; and the advantages of regular tactics began to be felt, by which generals were enabled to direct the movements of armies with greater exactness.

It became necessary to take mercenaries from the lowest classes of the people, and as military tactics, at the same time, reduced the art of war to a science, it required a more thorough and regular training. The individual and his prowess was lost in the mass of

regularly trained and disciplined officers; and standing armies were at length established, and rose continually in estimation.

Successive monarchs did much to improve and elevate the art of war, among whom were Henry IV., of France, and particularly Gustavus Adolphus, king of Sweden, who established smaller divisions, introduced lighter weapons, and made many improvements in artillery, by which quicker, and more complicated movements became practicable. Repeated victories proved the advantages of this new system, which even his celebrated opponent, Wallenstein, acknowledged. In the time of Louis XIV., the whole system received another form, under his minister of war, Le Tellier, and his son and successor Louvois, tactics being particularly improved by Turenne, and other contemporary generals. Standing armies attained at this period, an extent hitherto unexampled. Instead of 14,000 men, which was the extent of Henry IV.'s standing army, Louis XIV. brought 140,000 men into the field.

France having set the example, all the powers of Europe followed it, except England and Holland, who for a long time opposed the principle of increase to the army, regarding standing armies dangerous to freedom. A continually increasing scale measured its numbers, while France continually secured her boundaries by fortifications. Prussia particularly came forward under William I., and supported an army far exceeding the proportion of her population; whence she was induced to set the example of foreign levies. In this originated a difficulty hard to obviate, in the hour of danger; a large portion of the army could not be depended upon, and it was found almost impossible to maintain discipline over this portion, consisting of the refuse of foreign nations. The native soldiers, also, were corrupted by the association, and it was found necessary to reduce the army to a machine, in order to make such materials serviceable. This idea was put into execution by Frederic II. The system of standing troops was carried to such an extent as it had never reached before, and Prussian tactics became a pattern for all the other states of Europe. This system, however, had fatal imperfections. The great number of foreign vagabonds enlisted, led to the introduction of a degrading discipline, which made the condition of the soldiery completely miserable. Every prospect of advancement, and all ambition was destroyed, by the exclusive promotion of officers taken from the ranks of the nobility, and even their promotion was determined by the length of service. This system seemed to be carried to its height when the French revolution broke out, which shook Europe to the foundation.

Standing armies had now become bodies having little connection with the nations by which they were maintained. The mercenaries alone were armed; the nation had become altogether defenceless.

At the same time, the armies had become so much enlarged, beyond the proportionate wealth of the states, that they were in a great measure useless. They had become mere machines, without the slightest moral incentive. The consequence was, that when the burning and mad fury of the French populace became excited against the government, (and consequently against its unwieldy and rusty engines,) a new mode of carrying on war,—produced by the exigencies of circumstances, and by the rapid, bold, and energetic efforts of Napoleon—overturned multitudes of common and established forms, and carried victory in its train, until the opposing powers had learned to make it their model, and thereby restored the equilibrium. When Napoleon ultimately began to use his army more and more as a machine, for the promotion of his ambitious designs, then the other European powers, taught by experience, called the nations themselves to arms, in behalf of freedom; and it was demonstrated anew, that no excellence of discipline, no mechanical perfection of an army, can enable it to withstand, for any length of time, mental energy and excitement, though connected with far inferior discipline.

The armies on the continent of Europe, are generally raised at present from among the citizens, who are bound to serve for some time, and are then assigned to the class reserved for some sudden emergency. The time of service varies from three or four, to six or seven years. In the United States, no citizen is obliged to serve in the standing army, but only in the militia, which is destined merely for the defence of the country; and even this he can often avoid by paying a small commutation. The organization of armies is nearly alike throughout Europe; and all the great powers have paid much attention to the perfection of all classes of troops.

The military schools of all these countries for the officers of different rank, as well as for the various kinds of troops, particularly those of France and Prussia, are excellent. Among the Prussian troops, learning is so universally cultivated that the army is considered as a great institution for the diffusion of knowledge, because every Prussian serves without being allowed to send a substitute; and in each regiment, schools are kept for the privates. With respect to internal organization, the armies of the European continent surpass the British, in which the practice of selling commissions, the expense of the half-pay system, and the non-promotion of privates, remind us of the continental armies, such as they were sixty years ago. In the army of the United States, commissions are not sold; and the half-pay system has not been adopted. The artillery branch of its army is the most efficient in the world; and the cavalry and infantry tactics are on the most approved plan.

In modern times, we designate by the name of standing armies, bodies of troops, which, in time of peace, are kept under arms for the

defence of the state, within and without, trained to war, and paid by the government; whence the name of *soldiers*, from *solidus*, (Italian *soldo*,) a shilling, which was their daily pay. These troops may be composed of persons obliged to bear arms or not, of natives, or of foreigners. In this sense of the word, we find standing armies first in the monarchies of modern times, when the general introduction of fire-arms had changed the whole art of war, rendering personal courage of less consequence, and supplying its place with dexterity and mechanical skill, which can only be acquired through practice.

The first standing army consisted of mercenaries, assisted at first by the feudal militia, who gradually disappeared, as military service and discipline assumed a more systematic character by means of standing troops.

The introduction of standing armies has been generally referred to the reign of Charles VII., king of France, who, by means of them, overawed his rebellious vassals, and increased not a little the power of the crown.

King Philip Augustus, in consequence of the absence of great numbers of his vassals in the crusades, had introduced, as early as 1215, the "district levies," composed of the inhabitants of the cities and villages, of which no city furnished more than four hundred or five hundred. These served with the feudal militia, at the expense of the cities to which they belonged, and only at a certain distance from them. The power of the cities was thus increased, and the citizens formed in war a separate order, independent of the nobles. It was, in a great measure, owing to this cause, that they came to form a third estate in the administration of government.

These troops of Philip and his successors, consisted of feudal militia, of the "district levies," and of irregular troops, who were taken into pay, (whence the name *soldats*, or *soldiers*,) and formed into companies. The imperfection of the first class, who often made war on each other, and paid little regard to the public summons, and the rapine of the other, led Charles V. of France, to meditate a change, and Charles VII., to establish a better military system. After long consultation with the nobles, he laid the foundation, in 1445, by selecting fifteen captains, whom he ordered to choose the bravest men from the troops, and form them into as many companies. These were maintained, in war and peace, by the cities and villages. Henceforward the feudal militia fell more and more into disrepute, and the vassals assembled their forces only on occasions of great emergency. The feudal militia, however, was not wholly supplanted by mercenaries, until the eighteenth century. In 1448, Charles established a corresponding infantry, called *Free Archers*, which, in conjunction with the troops just described, constituted a

very respectable army. The military system, thus established in France, spread thence into the other countries of Europe.

With the progress of standing armies in France, and the increase of wealth, the standing armies of other countries increased also; especially those of Holland, England, and Germany. When this increase arrived at its highest point, and the decision of war became almost entirely dependent on numbers, the duty of military service was extended to all the citizens, and a system of conscription was introduced, (adapted to the condition, population, and the necessities of a state,) by which all the citizens of a certain age, capable of bearing arms, were called upon to do military duty, for a longer or a shorter period. In this way, standing armies and the military, considered as a separate profession, were, to a great degree, abolished; and all the citizens able to bear arms being disciplined for the protection of their country, and obliged to act for its defence, the number of troops became proportionate to the natural resources of the states; and military discipline became more liberal and honorable. Such has been the case, at least on the European continent, and the standing army is no longer the sole, and, with some governments, not even the chief military power. Malte Brun, in his geography, estimates the proportion in the principal states of Europe; but for the reason given below, the estimate is imperfect.

The European armies have of late been, and still are changing so rapidly in numbers, that the proportion which that of every country bears to the whole population cannot be given with any degree of accuracy. We can only say that, among the five great powers, those of Prussia and Russia bear the largest proportion, and that of Britain bears the smallest proportion to the total population of the country. In the last country, there is about 1 soldier to every 300 of the population of the British Isles, or 1 to every 1500 in the whole empire.

The United States of America have now on foot about 10,000 men, which is 1 to every 2100 of the population. The late war with Mexico demonstrated the efficiency of their army in a manner which excited the surprise of the European powers; and it proved, more clearly perhaps than it had ever been shown before, that it is skill, and mental energy and intelligence which makes the true warrior, and not mechanical tactics or brute force.

§ X.—Militias.

A *militia*, (literally, soldiery,) in the modern adaptation of the word, is a body of armed citizens, regularly trained, though not in constant service, in time of peace, and thereby distinguished from

standing armies. It includes all classes of the citizens, (with certain exceptions,) who are drilled at particular periods, and liable to march, in cases of emergency, against the enemy. The regular organization of the militia distinguishes it from a general levy. The militia exists in different countries under different names. Thus, in France, it is called *The National Guards;* among us the *Militia;* and in Austria and Prussia, *Landwehr*, or Defence of the Land.

In the times of the feudal system, each nobleman was a monarch in miniature, and kept his own warriors in his castle or territory: the difficulty of assembling a general army was immense, and the rebellious noblemen, at different periods, set royalty at defiance, defended their rights by means of their vassal warriors, and drawbridge castles, massively fortified, and occasionally menaced to overturn the government, and assert the rights of sovereigns in their own persons. The cities were, therefore, obliged to marshal in their own defence certain bodies of citizens, who were armed for the purpose of supporting the municipal and individual rights, and make head against opposing factions; and thus out of these circumstances, and a native republican spirit, first sprung the militia, for the defence of individual property and rights, from the incursion of internal enemies, as well as external foes.

The army of Sweden was, at an early period, a kind of general militia. The army consisted of twenty-one regiments, of which each owner of landed property was bound to maintain one man. They assembled for three weeks every year, and had a general muster, and during this time, as well as in war, received full pay. This was the case in Prussia till very recently. The Danish army followed the same plan; one third being enlisted foreigners, and two thirds native soldiers, who were supported by landholders, but were compelled to aid the latter, in the cultivation of their estates. In Germany similar plans were adopted. The privates and non-commissioned officers of the militia followed their agricultural or mechanical pursuits, and were generally under the command of officers out of active service. They were only obliged to serve within the country. Frederick the Great of Prussia used them to garrison fortresses. The same was the case with the Austrian militia. The bad organization, and unmilitary spirit of these troops, made them at all times a butt for ridicule to the troops of the line. In some cases, it was even considered allowable by the laws of war, not to give them any quarter, when they were employed out of the limits of the country, and were taken prisoners. They became extinct almost everywhere on the European continent. Similar, but better organized, was the English militia. The origin of the English militia is generally traced back to Alfred the Great. The feudal military tenures succeeded in that country; and, although the per-

sonal services required by this system degenerated by degrees into pecuniary commutations, or aids, the defence of the kingdom was provided for by laws requiring the general arming of the citizens; and lord lieutenants were appointed, in the reigns of Philip and Mary, for the purpose of keeping the counties in military order.

When Charles I., of England, issued, during his northern expeditions, commissions of Lieutenancy, and exerted certain military powers, as the prerogative of the crown, it became a question in the Long Parliament, how far the power over the militia did reside in the crown; which ended by the two houses of Parliament taking the entire power into their own hands. After the restoration of Charles II., the military tenures being abolished, the sole right of the crown to govern and command the militia, was acknowledged.

With regard to the militia of the United States, it was provided by an act of Congress in 1792, that all able-bodied white male citizens between the ages of 18 and 45, excepting clergymen, officers of government, members of Congress, mariners in service, &c., &c., should be enrolled in the militia. The persons so enrolled, were to provide themselves with common arms of infantry, and with ball, cartridges, &c., at their own expense. These were arranged into brigades, regiments, companies, &c., as the state legislatures might direct. Each battalion was to have at least one company of grenadiers, light infantry, or riflemen; and each division at least one company of artillery. Proper ordnance and field artillery was to be provided by the government. The cavalry and artillery troops were to consist of volunteers from the militia at large, not exceeding one company to each regiment, and to equip themselves, with the exception of the ordnance above-mentioned. The substance of these enactments is still retained; although many alterations have since been made. The present militia force of the United States is nearly two millions; and the results of the late Mexican war prove that, notwithstanding the ridicule with which citizen soldiers have been sometimes assailed in this country, as well as by the mercenaries of European monarchs, an efficient army can readily be levied from them, adequate to meet any emergency. It is to be hoped, however, that there may never be any occasion for their giving a practical exhibition of their strength.

§ XI.—Balance of Power.

Among states, this is a principle of foreign policy intimately connected with the general peace and independence of nations, but which some have treated as chimerical, while others have represented it as having led only to pernicious results. It is more generally ad-

mitted, however, to have a real foundation in the rules of intercourse and union among states, and to have exercised a great influence on the affairs of modern Europe. Though the policy in question was not wholly unknown to other ages and countries, it was nowhere systematically pursued but among the European nations of modern times.

Previous to the sixteenth century, there was little political connection among the European nations, their circumstances being such as not to admit of any regulated attention to foreign affairs; but, about the commencement of that century, they began to form one grand community, or federal league, of which the actuating principle was the preservation of the balance of power. Attention to this principle thenceforth influenced all the great wars and negotiations, and made every foreign movement, however remote, an object of interest, throughout every part of the system.

The ultimate intention of the system founded on the balance of power is, to secure every state in the full possession and enjoyment of all its rights, by making its safety and independence objects of interest and guardianship to its neighbors. It endeavors to accomplish this great end, by teaching that it is the interest of all states to check the first encroachments of ambition, to watch every movement of foreign powers, and to unite their respective forces in support of the weak against the strong. It is called the *balancing* system, because its aim is to prevent any state from aggrandizing itself at the expense of its neighbors, and to counterpoise any state that may have become too powerful by a union of the forces of others; and this union is recognized by the term *allied powers.*

It has sometimes been supposed that its object was to equalize the powers of states composing a common system; and as it is plainly impossible either to effect or to maintain such an equality, it has thence been concluded, that the whole system is founded upon a chimera. But, with a view to the real objects of it the question is not what amount of power above another any state possesses, provided the power so possessed be fairly acquired, but whether any state possesses its power in such circumstances as to enable it to trespass at pleasure on a weaker neighbor. If there be no other state or confederacy of states capable of counteracting any injurious designs which a greater power might undertake, then it is said there is no balance; but, if there be such a counterpoise, this is all that the balancing system requires to produce what, in its language, is called an equilibrium. In order to make this point as clear as possible, we beg leave to refer to the following definitions of the balance of power given by Vattel, and by Gentz. "By this balance," says the former, "is to be understood such a disposition of things as that no one potentate or state shall be able absolutely to predominate

and prescribe laws to the others." (Law of Nations, B. 3d, Chap. 3d, § 47.) "What is usually termed balance of power," says Gentz, "is that constitution subsisting among neighboring states, more or less connected with one another, by virtue of which no one among them can injure the independence or essential rights of another, without meeting with effectual resistance on some side, and consequently exposing itself to danger." (Fragments on the Political Balance, chapter first.)

Thus, then, it is distinctly understood, that the balancing system is not grounded upon an equality among states, in respect of power, but upon a union of powers to repress the enterprises of the strong and ambitious, and to counteract the effects of necessary individual inequalities by aggregate strength. It is quite indispensable to the existence of such a system, that one state should not be permitted to obtain such a superiority of power as to enable it to overawe all opposition, and make the safety of those around it dependent upon its will. And, as it is the disposition of all unchecked power to extend itself, the balancing system inculcates it as the interest as well as the right of every state to join in opposing the first encroachments of any ambitious potentate or community. It teaches that the danger extends much further than to the party immediately attacked or menaced; that one encroachment will pave the way to another; and that it is therefore wise to meet the danger while yet distant, and capable of being combated with less peril or loss. The right of interference to put down a danger of this kind is, in fact, only a modification of the right to resist an immediate attack. All human experience shows that the state which is suffered to aggrandize itself, at the expense of one neighbor, will, with its increased means, acquire stronger dispositions to encroach much further; and therefore self-defence authorizes us to treat as an invader any potentate whose conduct entitles us to conclude that he only waits an opportunity to become so in effect. "As long," says Bacon, "as men are men, and as long as reason is reason, a just fear will be a just cause of preventive war; but especially, if it be part of the case, that there be a nation who is manifestly detected to aspire to new acquests, then other states, assuredly, cannot be justly accused, for not paying for the first blow, or for not adopting Polyphemus's courtesy, to be the last to be eaten up." (Speech concerning a war with Spain.) This is peculiarly and emphatically the language of the balancing system, viz., "Look well to the safety and independence of your neighbors, even the most remote, if you wish to preserve your own." The principle of interference to prevent the progress of a dangerous power rests, both as to right and policy, upon the most obvious dictates of experience and prudence. No state ever yet acquired a preponderating power, without abusing it;

and therefore, it is the right and interest of all states, to prevent any one from rising to such an ascendency as may endanger the common safety. The right in question, however, is that of guarding against injury justly to be apprehended from the conduct of a state which uses improper means of aggrandizement. As far, therefore, as measures of hostility are concerned, there must be actual encroachment in order to warrant them. The balancing system does not say there shall be no alterations in the relative strength of states; for a state may fairly and honorably increase her power by wise legislation, or by the cultivation of her own internal resources. To attempt to impede a state, which takes this road to greatness, would be to make war upon those very arts, by the successful cultivation of which, peace and happiness are diffused through the world. The aggrandizements to which the balancing system is opposed, are those attended with immediate violence to some, and which infer violence to others. All that nations can do, when a neighbor becomes formidable in a fair way, is to watch her, and to draw closer those ties of alliance which may enable them to counteract any bad use of her power. When Lord Bacon, in his essay on Empire, counsels princes to "keep due sentinel, that none of their neighbors should so overgrow by increase of territory, by commerce, or the like, as to become more able to annoy them," he does not mean that the growth of a state by commerce is to be prevented, as in case of his extension by seizure of territory; but that all great power, however acquired, is dangerous in its nature, and ought to be counterpoised by timely confederation.

There is another way in which a state may become formidable, and that of a sudden, where the balancing system does not authorize immediate hostile interference. We allude here to the case of a sovereign who acquires a great accession of power by marriage, or by inheritance. "It is a sacred principle of the law of nations," says Vattel, "that such an increase of power cannot, alone and of itself, give any one a right to take up arms, in order to oppose it." Grotius and Puffendorf maintain the same opinion, in decided terms. But suppose a sovereign who has displayed an encroaching disposition, is about to acquire, in this way, an accession of power which would render him formidable to his neighbors; in this case, as Vattel shows, the maxims of the balancing system authorize an immediate interference to procure securities, or, according as the danger is eminent, to prevent altogether the impending aggrandizement. "It is, perhaps, unprecedented," says Vattel, "that a state should receive any remarkable accessions, without giving other states just grounds to interfere; but should it be otherwise, the balancing system recommends keeping a watchful eye upon that state or that power, and the formation of a counterpoise by means of alliances." The grand

expedients of the balancing system, therefore, are vigilant inspection to discover, and prompt union to counteract in their birth, all such projects of encroachments as powerful states will ever, when opportunity offers, be ready to form. By employing resident agents to procure speedy information, and by the weight of joint warnings and reclamations, in every case of apprehended or of real injury, the balancing system is supposed to furnish the only peaceful means, which human wisdom can devise, to control the conduct of independent states, the only means which can be employed to guard against injustice, or obtain redress without actual appeal to the sword.

It was the habitual employment of these expedients, with a view to guard against distant dangers, that distinguished the balancing system, as exemplified in modern Europe, from those momentary efforts, and loose confederacies, in which all nations, and even the rudest tribes, have occasionally united, in order to repel or pull down a common enemy.

The object of the system is always the same, viz.: to preserve such a distribution of power, amid the varying relations of states, as shall most effectually check the spirit of encroachment, and confine every potentate to his own dominions.

The preceding observations attempt to give a general idea of the nature, intention, and means of maintaining a balance of power among a number of connected nations of different degrees of power and magnitude. We shall finish by a few remarks on the history and results of this branch of policy.

The fundamental maxims which, according to Ghentz, constitute the necessary conditions of the beneficial existence of such a system are—1st. That no one state in the common system, must ever become so powerful as to be able to coerce all the rest put together. 2d. That if the system is not merely to exist, but to be maintained, without constant perils and violent concussions, every member who infringes it, must be in a condition to be coerced, not only by the collective strength of the other members, but by any majority of them, if not by one individual. 3d. That if ever a state attempts, by unlawful enterprise, to attain, or does in fact attain to a degree of power which enables it to defy the danger of a union of several of its neighbors, or even of the whole, such a state should be treated as a common enemy; and if that state has acquired such a degree of force by accidental circumstances, without any violence whatever, whenever it appears on the public theatre, no means which political wisdom can devise for the purpose of diminishing its power should be neglected or left untried, whenever it appears on the public scene of action.

The knowledge of the ancients with regard to these great principles of national safety, and the period when they obtained a decided

influence among the moderns, are points of considerable historic interest.

Mr. Hume has proved, in a very satisfactory manner, that the principle of preserving a balance of power, is distinctly to be recognized in many of the great political transactions of the ancient world. The same thing had previously been shown by Kahle, a famous physician, in a learned work published at Berlin in 1744. The anxiety of the Greeks, with regard to the principle of equilibrium among states, was particularly manifested, in that famous league against the rising power of Athens, which produced the Peloponnesian war. Athens herself showed that she both knew and practised this policy, by constantly throwing her power into the lighter scale, when Thebes and Sparta came to contend for the mastery of Greece. The orations of Demosthenes frequently display very clear views, and extensive ones, in this branch of policy. "In that for the Megalopolitans, we may see," according to Mr. Hume, "the utmost refinements in the balance of power that ever entered into the head of a Venetian or an English speculatist;" and by a later writer, Brougham, in his "Colonial Policy," this speech is also pointed out as containing discussions of some of the most delicate parts of the theory. It seems, in short, to be no longer a question, that it was only with the phrase, and not the idea of a balance of power, that the ancients were unacquainted. It was the more constant operation of the principle in question which gradually formed the nations of Europe into one great republic, or federal league, whose common bond of union was the guarantee which it afforded of their respective independence.

In modern Europe, a number of considerable states were formed, under such circumstances as tended peculiarly to promote a regular intercourse among them, and, consequently, to develop and systematize this great principle of national security. But it did not begin to manifest itself until, in the gradual and similar progress of European society, the power of the sovereigns of these states was so far consolidated as to enable them to give a part of their attention to foreign affairs, and to maintain armies beyond their own frontiers. It was in Italy, where civilization was more advanced, and where there existed a number of small states and commonwealths, whose safety required that they should keep watch on each other, that the modern system of interference took its beginnings. From an early period of the fifteenth century, we see the balance of power as constant an object of concern among these states, as in the sixteenth century it became an object of concern throughout the whole of Europe. Guicciardini, in his Italian History, presents a splendid picture of the beneficial effects, the long peace, and general independence, attendant upon this habitual attention to the balancing principle. It was about

the end of the same century, that these ideas began to extend to other quarters, and to actuate the movements of greater potentates. There were even then several princes possessed of large kingdoms, with powers and prerogatives which enabled them to take part in different wars and negotiations. The first great movements of an ambitious neighbor would naturally excite their jealousy, and bring them to act in concert. Thus when Charles VIII., of France, invaded Italy, in 1494, and laid claim to Naples, the sovereigns of Spain and Germany saw the expediency of listening to the Italian princes, who suggested a confederacy to prevent France from gaining an accession of power which could not but render her a dangerous neighbor. During that triumvirate of kings, Henry VIII., of England, Francis I., of France, and Charles V., Emperor of Germany, there was such a watch kept over them, that none of the three could win a rood of ground, but the other two would immediately balance it, either by confederation, or by a war, if necessary.

"Long before the states of Europe," (says M. Villers, in his able work on the Reformation,) "became united in a general system, Italy and Germany had formed partial systems, with a view to restrain the members within them, each by the other, and maintain a balance of power." The states of Europe embraced the idea of a balance of power, in proportion as their circumstances enabled them to act upon it, and not in consequence of any estimate of its effects, as displayed on those narrower and earlier stages of its agency. The object, therefore, of a balance of power, is to alarm and arm all against the prince, whose power prompts him to transgress upon others; and the prince who knows that all his motions are keenly watched, and that his first successes would only expose him to a more extended contest, must see how hopeless must be any attempt to possess himself of the territories of the weakest of his neighbors.

The great changes to which the American revolution opened the door, have rendered the doctrine of the balance of power of less consequence than formerly. The great object of jealousy among European monarchs now is, not their *neighbors*, but *their own subjects*. They fear the rising power of democracy, much more than they fear each other. They have been made aware, in short, that hereafter, they will have to contend, not for more territory, but for their crowns and revenues. The immense strides of this young republic towards irresistible power, combined with the striking and increasing prosperity which attends its growth, fills them with alarm. They see, also, their subjects will be apt to conclude that crowned heads, state-paid priests, and a privileged class of nobility, are things not essential to public prosperity, or private morality, but rather a heavy incubus on both; and the many attempts very recently made in many parts of Europe to establish republican governments, clearly

inform us that many of the masses have already learned that lesson. Throughout the greatest part of Europe, the ambitious views, and private wishes of rulers, are beginning to be controlled by the views and wishes of their subjects. These are beginning to open their eyes to the legitimate objects of government.

"The right divine of kings to govern wrong"

has been so completely exploded, that it is likely to be even forgotten, at no distant period. Absolutists are now obliged to trust mainly to brute force, to keep down their subjects, and in such circumstances, the balance of power is not likely ever again to assume the importance it once held. To the New World, it cannot apply: for here the whole weight is already in one scale; and the diabolical partition of Poland, perpetrated when the system was yet in full vigor, proves that its value was much less than it was once estimated.

PART IV.

PUBLIC ECONOMY.

§ I.—Balance of Trade.

Balance of trade is the term commonly used to express the difference between the value of the exports from, and the imports to, a country. The balance is said to be favorable, when the value of the exports exceeds that of the imports—and unfavorable, when the value of the imports exceeds that of the exports. The attainment of a favorable balance was formerly regarded as an object of the greatest importance. The precious metals, gold and silver, early acquired, in consequence of their being used as money, an artificial importance, and were long considered as the only real wealth either individuals or nations could possess. And as countries without mines could not obtain supplies of these metals, except in exchange for exported products, it was concluded that if the value of the commodities ex-

ported, exceeded that of those imported, the balance would h
be paid by the importation of an equivalent amount of the p
metals, and conversely. A very large proportion of the re
imposed on the freedom of commerce, during the last two cer
grew out of this notion. The importance of having a favorab
ance being universally admitted, every effort was made to att
and nothing seemed so effectual for this purpose, as the devis
schemes to facilitate exportation, and hinder the importation of
all products that were not intended for future exportation, excep
and silver. But the gradual, though slow growth of sounde
ions, with respect to the nature and functions of money, show
futility of a system of policy having such objects in view. It
conceded that gold and silver are nothing but commodities
that it is in no respect necessary to interfere, either to enc
their importation, or to prevent their exportation. In Great B
they may be freely exported and imported, whether in the sha
coin or bullion.

The truth is, however, that the theory of the balance of t
not erroneous merely from the false notions which its advocat
tertained with respect to money; it proceeds on radically mi
views, as to the nature of commerce. The mode in which th
ance is usually estimated, is, indeed, completely fallacious. S
sing, however, that it could be correctly ascertained, it wou
found, in opposition to the common opinion, that the import
every country that maintains a commerce with another, ger
exceeds the exports; and that when a balance is formed, it is c
certain cases that it is cancelled by a specie payment.

The proper business of the wholesale merchant, consists in
ing the various products of the different countries of the world
the places where their value is least to those where it is greates
what is the same thing, in distributing them according to the ef
demand. It is clear, however, that there could be no motive
port any species of produce, unless that which it was intend
import in its stead, were of greater value. When an English
chant commissions a quantity of Polish wheat, he calculates o
ing for so much more than its price in Poland, as will be suf
to pay the expense of the freight, insurance, &c., and to yiel
sides, the common and ordinary rate of profit on the capital emp
If the wheat did not sell for this much, its importation would
ously be a loss to the importer. It is plain, then, that no mer
ever did, or ever will export, but with a view of importing some
else more valuable in return. And so far as the excess of ex
over imports being any criterion of an advantageous commerce
directly the reverse; and the truth is, notwithstanding all tha
been said and written to the contrary, that unless the value o

imports exceeded that of the exports, foreign trade could not be carried on. Were this not the case, that is, were the value of the exports always greater than the value of the imports, merchants would lose on every transaction with foreigners, and the trade with them would be speedily abandoned.

In England, the rates at which all articles of export and import are officially valued, were fixed so far back as 1696. But the very great alteration which has since taken place, not only in the value of money, but also in the cost of most part of the commodities produced in that and other countries, has rendered this official valuation, though valuable as a means of determining their quantity, of no use whatever as a criterion of the true value of the exports and imports. In order to remedy this defect, an account of the true and declared value of the exports is prepared, from the declarations of the merchants, and laid before Parliament; there is, however, no such account of imports. And, owing to the difficulties which high duties throw in the way, it is, perhaps, impossible to frame one with anything like accuracy. It has also been alleged, and apparently with some probability, that English merchants have not unfrequently been in the habit of exaggerating the value of articles entitled to drawbacks on exportation. But the recent extension and improvement of the warehousing system, and the diminution of the number of drawbacks, must materially lessen whatever fraud or inaccuracy may have arisen from this source. Indeed, as most articles were charged with an ad valorem duty of 10 shillings per cent. on exportation, we should consider that their value would be rather under than over-rated. We believe, however, that their declared value comes very near the truth; at least, sufficiently so for all practical purposes. Now the declared value of the English exports in 1832, was only £36,046,027, being little more than half their official value, and upwards of £7,000,000 under the official value of the imports. What the excess of the latter might be, had we the means of comparing their real value with that of the exports, it is impossible to say; but there can be no manner of doubt, that, generally speaking, it would be very considerable. The value of an exported commodity is estimated at the moment of its being sent abroad, and before its value is increased by the expense incurred in transporting it to the place of its destination; whereas, the value of the commodity imported in its stead, is estimated after it has arrived at its destination, and, consequently, after its value has been enhanced by the cost of freight, insurance, importer's profits, &c.

In the United States, the value of the imports, as ascertained by the custom-house returns, generally exceeds the value of the exports. And, although our practical politicians have been in the habit of considering the excess of the former as a certain proof of a

disadvantageous commerce, that is, a surplus of imports, the real gain of the United States has been nearly in proportion as the value of their imports has exceeded that of their exports. The great excess of American imports has been occasioned in part by the Americans generally exporting their own surplus produce, and consequently receiving from foreigners, not only an equivalent for their exports, but also for the cost of conveying them to the foreign market.

"In 1811," says Mr. Pitkin, "flour sold in America for nine dollars and a half per barrel, and in Spain for fifteen dollars." The value of the cargo of a vessel, carrying 5,000 barrels of flour, would therefore be estimated at the period of its exportation, at $47,500; but, as this flour would sell, when carried to Spain, for $75,000, the American merchant would be entitled to draw on his agent in Spain, for $27,500 more than the flour cost in America, or than the sum for which he could have drawn, had the flour been exported in a vessel belonging to a Spanish merchant, and on his account. But the transaction would not end here. The $75,000 would be vested in some species of Spanish, or other European goods, fit for the American market, and the freight, insurance, &c., on account of the return cargo, would probably increase its value to $100,000; so that, in all, the American merchant might have imported goods worth $52,500 more than the flour originally sent from Spain. It is as impossible to deny that such a transaction as this is advantageous, as it is to deny that its advantage consists entirely in the excess of the value of the goods imported over the value of those exported. And it is equally clear, that America might have had the real balance of payments in her favor, though such transactions as the above had been multiplied to any conceivable extent. Thus we see there is no connection between an unprofitable trade and an apparent preponderance in the value of imports.

In the second place, when a balance is due by one country to another, it is seldom paid by remitting specie from the debtor to the creditor country. If the sum due by the British merchants to those of the United States be greater than the sum due by the latter to them, the balance of payments will be against Britain; but this balance will not, and indeed cannot, be discharged by an exportation of bullion, unless bullion be at the time the cheapest exportable commodity; or which is the same thing, unless it may be more advantageously exported than anything else. To illustrate this principle, let us suppose that the balance of debt, or excess of the value of the bills drawn, by the merchants of New York on London, over those drawn by the merchants of London on New York, amounts to £100,000, it is the business of the London merchants to find out the means of discharging this debt with the least expense; and it is

plain that, if they find that any less sum, as £96,000, will purchase, and send to New York, as much cloth, cotton, hardware, colonial produce, or any other commodity, as would sell in New York for £100,000, no gold or silver would be exported. For they will export goods to that amount, and then draw on their New York consignees, in favor of their creditors. The laws which regulate the trade in specie, are not, in any degree, different from those which regulate the trade in other commodities. Specie is exported only when its exportation is advantageous, or when it is more valuable abroad than at home. It would in fact be quite as reasonable to expect that water should flow from a low to a high level, as to expect that specie should leave a country, where its value is great, to go to one where its value is low. Specie is never sent abroad to destroy, but always to find its level.

The balance of payments might be ten or a hundred millions against a particular country, without causing the exportation of a single ounce of specie. Common sense tells us that no merchant will remit $100 worth of specie to discharge a debt in a foreign country, if it be possible to invest any smaller sum, in any species of merchandise which would sell abroad for $100 dollars exclusive of expenses. The merchant who deals in the precious metals, is as much under the influence of self-interest as he who deals in coffee or indigo. But what merchant would attempt to extinguish a debt, by exporting coffee which cost $100, if he could effect his object by sending abroad indigo which cost only $99?

The argument about the balance of payment is one of those that contradict and confute themselves. Had the apparent excess of exports over imports, as indicated by the British custom-house books for the last hundred years, been always paid in bullion, as the supporters of the old theory contend is the case, there ought, at this moment, to be in Britain, about £450,000,000 or £500,000,000, instead of £50,000,000 or £60,000,000, which is the actual amount! Nor is this all. If the theory of the balance be good for anything; if it be not a mere idle delusion, it follows, as every country in the world, with the single exception of the United States, has its favorable balance, that they must be paid by an annual importation of bullion from the mines, corresponding to their aggregate amount. But it is a well-known fact that the amount of specie in a country varies very little from year to year: and it is certain that the entire produce of the mines, though it were increased in a tenfold proportion, would be insufficient for this purpose! This *reductio ad absurdum* is, therefore, decisive of the degree of credit that ought to be attached to the conclusions respecting the flourishing state of the commerce of any country, drawn from the excess of the exports over the imports.

Not only, therefore, is the common theory with respect to the balance of trade erroneous, but the very reverse of that theory is true. In the first place, the value of the commodities imported by every country, which carries on an advantageous commerce, (and no other will be prosecuted for any considerable period,) invariably exceeds the value of those which she exports. Unless such were the case, there would plainly be no fund, whence the merchants and others engaged in foreign trade could derive either a profit on their capital, or a return for their outlay and trouble; and in the second place, whether the balance of debts be for or against a country, that balance will neither be paid nor received in bullion, unless it be, at the time, the commodity, by the exportation or importation of which, the account may be most profitably settled. Whatever the partisans of the doctrine as to the balance may say about money being a preferable product, it is certain it will never appear in the list of exports and imports, while there is anything else with which to carry on trade, or cancel debts, that will yield a larger profit, or occasion less expense to the debtors.

It is difficult to estimate the mischief which the absurd notions relative to the balance of trade have occasioned in every commercial country. But in America, they have been particularly injurious. It is chiefly to the prevalence of prejudices to which they have given rise, that the restrictions on the trade between America and Europe are to be ascribed. The great, or rather, the only argument insisted upon, by those who prevailed on the British legislature, in the reign of William and Mary, to declare the trade with France a nuisance, was founded on the statement that the value of the imports from that kingdom, considerably exceeded the value of the commodities exported to it. The balance was regarded as a tribute paid by England to France; and it was sagaciously asked, what had they done, that they should be obliged to pay so much money? It never occurred to those who so loudly abused the French trade, that no merchant would import any commodity from France, unless it brought a higher price in England than the commodity exported to pay for it, and that the profit of the merchant, or the national gain, would be in exact proportion to this excess of price. The very reason assigned for prohibiting the trade, affords the best attainable proof that it was a lucrative one.

There are some circumstances which have had an influence in determining the relation of exports to imports in the United States, and which are in a great measure peculiar to this country. These, it may not be uninteresting briefly to mention. Our readers will bear in mind, that we use the terms exports and imports in their ordinary and mercantile acceptance, including all sorts of commodities, specie only being excepted. 1st. While the exports have been valued

at the exporting port, the imports, until the 3d day of March, 1833, were valued by adding 20 per cent. to the actual cost, if imported from the Cape of Good Hope, or from any other place or country, including all charges, commissions, outside packages and insurance alone excepted. 2d. The profits of capital being higher in the United States than in most other countries of the commercial world, it follows that capital must be continually flowing into them from abroad, thus swelling the imports beyond the amount they otherwise attain. For much of the money borrowed abroad, is laid out on imported goods; and if money could not be borrowed so freely, the amount of imported goods would necessarily be less. 3d. The owner of the capital imported into the country does not, in many cases, come with his property, but continues to reside where he did. A certain amount of profits, or interest, on the foreign capital employed in the United States, is consequently remitted every year to other countries. And as this is partly in goods, it is obvious that our exports will, on this account, be rendered more considerable in comparison to our imports. 4th. The rapid advance of the country in population and wealth, since its separation from Great Britain and the adoption of the present constitution, has required a supply of the precious metals, for the most part from abroad, much greater than was sufficient to replace the consumption of those metals, either as coin or in the arts. Money was, therefore, to a certain extent, on this acconnt, imported into the United States, in exchange for our exports, instead of those commodities which are ordinarily designated by the term imports. 5th. The substitution, in a degree continually greater and greater, of paper money for a gold and silver currency, which has been taking place during the same period, must of course have diminished the effect just stated.

If we now put these different circumstances together, two of them operating in one direction, and the other three in the opposite; and if we compare them also with those which are not peculiar to the United States, but belong equally to every country, there will be no cause for surprise, why the general law of the excess of imports over exports, should almost always have held good among ourselves.

§ II.—Origin of Commerce and Mercantile Classes.

The origin of commerce* is coeval with the first dawn of civilization. As soon as individuals ceased to supply themselves directly

* This word is derived from com-mutatio merc-ium; and means properly what the term literally imports—an exchange of commodities. It is in this sense we employ it in the present section. In a narrower signification, it means exchanging commodities with foreigners.

with the goods they used, a commercial intercourse must have begun to grow up amongst them. For it is only by exchanging that portion of the produce, raised by ourselves, that exceeds our own consumption, for portions of the surplus produce raised by others, that the division of employments can be introduced, or that different individuals can apply themselves to different pursuits.

Not only, however, does commerce enable the inhabitants of the same village or parish, to combine their separate efforts to accomplish some common object, but it also enables those of different provinces and kingdoms to apply themselves, in a special mannner, to those callings, for the successful prosecution of which the district or country which they occupy gives them some peculiar advantage.

The territorial division of labor has contributed more, perhaps, than anything else to increase the wealth and accelerate the civilization of mankind. Were it not for it, we should be destitute of a vast number of the comforts and enjoyments which we now possess; while the price of the few that would remain would, in most instances, be very greatly increased. But whatever advantages may be derived, (and it is hardly possible to exaggerate, either their magnitude or their importance,) from availing ourselves of the peculiar capacities of production enjoyed by others, are wholly to be ascribed to commerce, as their real source and origin.

While the exchange of different products is carried on by the producers themselves, they must unavoidably lose a great deal of time. and experience many inconveniences. Were there no merchants, a farmer, wishing to sell his crop, would be obliged in the first place to seek for customers, and to dispose of his corn as nearly as possible in such quantities as might suit the demands of the various individuals inclined to buy it; and, after getting its price, he would next be obliged to send to ten or twenty places, and these perhaps remote, for the commodities he wanted in its stead; so that, besides being exposed to an immense deal of trouble and inconvenienee, his attention would continually be diverted from the labors of his farm. Under such a state of things, the work of production, in every different employment, would be meeting with perpetual interruptions; and many branches of industry, that are carried on in a commercial country, would not be undertaken. The establishment of a distinct mercantile class, effectually obviates these difficulties. When a set of dealers erect warehouses and shops, for the purchase and sale of all descriptions of commodities, every producer, relieved from the necessity of seeking customers, and knowing beforehand where he may at all times be supplied with such products as he requires, devotes his whole time and energies to his proper business. The intervention of merchants gives a continuous and uninterrupted motion to the plough and the loom. Were the class of traders annihilated,

all the springs of industry would be paralyzed. The numberless difficulties that would then occur in effecting exchanges, would lead each particular family to endeavor to produce all the articles they had occasion for; the divisions of labor would be relinquished; and the desire to rise in the world, and improve our condition, would decline, according as it became more difficult to gratify it. What sort of agricultural management could be expected of farmers who had to manufacture their own wool, tan their own hides, make their own clothes, paper, writing materials, books, shoes, &c., and who were every now and then obliged to leave the plough for the shuttle—and the harrow for the anvil, and the plane?

A society, without that distinction of employments and professions resulting from the division of labor, that is, without commerce, would be totally destitute of any arts or sciences worthy of the name. It is by the assistance that each individual renders to, and receives from his neighbors, by every one applying himself, through preference, to some particular task, and combining, though probably without intending it, his efforts with those of others, that civilized man becomes equal to the most gigantic labors, and effects what at first sight appears beyond his power.

The mercantile class has generally been divided into two subordinate classes, viz.: wholesale dealers, and retail dealers. The former purchase large quantities of the various products of art and industry in the places where they are produced, or are least valuable, and therefore cheapest, and carry them to those places where they are most valuable, or more in demand; and the retail dealers, having purchased the commodities in smaller quantities of the wholesale dealers, or of the producers, collect them in shops, and sell them in such quantities, and at such times, as may best suit the public demand.

These classes of dealers are alike useful; and the separation that has been effected between their employments, is one of the most advantageous divisions of labor. The operations of the wholesale merchant are analogous to those of the miner; neither one nor the other makes any change on the articles which he carries from place to place. All the difference is, that the miner carries them from below the ground, to the surface of the earth; while the merchant carries them from one place to another on the surface of the earth. Hence it follows, that the value given to commodities by the operations of the wholesale merchant, may often exceed that given to them by the producers. The labor and expense required to dig a quantity of coal from the mine, does not equal that required for its conveyance from Carbondale to St. Louis; and it is a far more difficult and costly affair to bring a piece of timber from Aroostook to New York, than to cut down the tree. In this respect, there is no difference between commerce, and agriculture, and manufactures. The latter

render materials useful, by bestowing on them such a shape as may best fit them for ministering to our wants and comforts; and the former gives additional utility to the products of the agriculturist and manufacturer, by bringing them from where they are of comparatively little use, or are in excess, to where they are of comparatively great use, or are deficient.

If the wholesale merchant were himself to retail the goods he has brought from different places, he would require a proportional increase of capital, and it would be impossible for him to give that exclusive attention to any department of his business which is indispensable to its being carried on in the best manner. It is for the interest of each dealer, as of each workman, to confine himself to some one business. By this means, each trade is better understood and cultivated, and carried on in the cheapest manner possible. But whether carried on by a separate class of individuals or not, it is obvious that the retailing of commodities is indispensable. It is not enough that a cargo of tea should be imported from China, or a cargo of sugar from Cuba: most individuals have some demand for these articles; but there is not perhaps a single private person throughout the United States requiring so large a supply of them for his own consumption. It is clear, therefore, that they must be retailed, that is, sold in such quantities, and at such times, as may be most suitable for all classes of customers, or consumers. And, since it is admitted on every side that this necessary business will be best conducted by a class of traders distinct from the wholesale dealers, it is impossible to doubt that their employment is equally conducive with that of others to the public interest, or that it tends equally to augment national wealth and comfort.

§ III.—Home Trade.

The commercial intercourse between the subjects of the same government is termed the *home trade*, or more simply *trade*, which is distinguished from *foreign trade*, or *commerce*, in the narrower sense. The observations already made serve to show the influence of the home trade, in allowing individuals to confine their attention to some one employment, and to prosecute it without interruption. But it is not in this respect only that the establishment of the home trade is advantageous. It is so in a still greater degree, by allowing the inhabitants of the different districts of a country to turn their labor into those channels in which it will be most productive. The different minerals, soils, and climates of different districts, fit them for being appropriated in preference to certain species of industry. A district, where coal is abundant, which has an easy access to the

ocean, and a considerable command of internal navigation, is naturally suited for manufactures: wheat and other species of grain are the natural products of rich, arable soils; and cattle, after being reared in mountainous districts, are most advantageously fattened in meadows and low grounds. Hence, it follows, that the inhabitants of different districts, by confining themselves to those branches of industry, for the successful prosecution of which they have some peculiar capability, and exchanging their surplus produce for that of others, will obtain an incomparably larger supply of all sorts of useful and desirable products than they could do were they to apply themselves indiscriminately to every different business.

The territorial division of labor is, if possible, even more advantageous than its division among individuals. A person may be what is called Jack of all trades; and, though he may not be well skilled in any, he may make some common efforts in them all. But it is not possible to apply the same minerals, and the same soil to every different purpose. Hence it is that the inhabitants of the richest and most extensive country, provided it were divided into small districts without any intercourse with each other, or with foreigners, could not, however well labor might be divided among themselves, be otherwise than poor and miserable. Some of them might have a superabundance of corn, at the same time that they were wholly destitute of coal and iron, while others might have the largest supplies of the latter articles with very little grain. But in commercial countries, no such anomalies can exist. Abundance and comfort may there be universally diffused. The labors of the mercantile classes enable the inhabitants of each district to apply themselves chiefly to those employments which are naturally best suited to them. This superadding of the division of labor, among different provinces, to its division among different individuals, renders the productive powers of industry immeasurably greater, and augments the mass of necessaries, conveniences, and enjoyments, in a degree that could not previously have been conceived possible, and which cannot be exceeded, except by the introduction of foreign trade, or commerce. "With the benefits of commerce," says an eloquent and philosophical writer, "or a ready exchange of commodities, every individual is enabled to avail himself to the utmost of the peculiar advantages of his place;—to work on the peculiar materials with which nature has furnished him;—to humor his genius or disposition, and betake himself to the task in which he is peculiarly qualified to succeed. The inhabitant of the mountain may betake himself to the culture of his woods and manufacture of his timber; the owner of pastures may devote himself to the care of his herds; the owner of the clay-pit to the manufacture of his pottery; and the husbandman to the culture of his fields, or the rearing of his cattle. And any one

commodity, however it may form but a small part in the accommodations of human life, may, under the facilities of commerce, find a market in which it may be exchanged for what will procure any other part or the whole; so that the owner of the clay-pit, or the industrious potter, without producing any one article immediately fit to supply his own necessities, may obtain possession of all he wants. And commerce, in which it appears that commodities are merely exchanged, and nothing produced, is, nevertheless, in its efforts, very productive, because it ministers a facility and encouragement to every artist, in multiplying the productions of his art; thus adding greatly to the mass of wealth in the world, and being the occasion that much is produced." See Ferguson's *Principles of Moral Science.*

The roads and canals that intersect a country, and open an easy communication between its remotest extremities, render the greatest service to internal trade, and to agriculture and manufactures. A diminution of the expense of carriage has, in fact, the same effect as a diminution of the direct cost of production. If the coals brought into a city sell at $6 00 per ton, of which the carriage amounts to half, it is plain, that in the event of an improved communication, (such as a more direct or level road, a railway or a canal being opened,) for the conveyance of the coals, and that they can, by this means, be imported for half the previous expense, their price will immediately fall to $4 50 a ton,—just as it would have done, had the expense of extracting them from the mine been reduced to half.

Employments are more and more divided, (or rather subdivided,) more powerful machinery is introduced, and the productive powers of labor are increased, according as larger masses of the population congregate together. In a great town, the same number of hands will perform much more work than in a small village, where each individual has to perform several operations, and where the scale of employment is not sufficiently large to admit of the introduction of extensive and complicated machinery. But many of the great towns could not exist without our improved means of communication. These, however, enable their inhabitants to supply themselves with the bulky products of the soil, and of the mines, as cheap, or nearly so, as if they lived in the country villages; securing to them all the advantages of concentration, with but few of its inconveniences.

Roads and canals are thus productive of a double benefit; for, while, by affording comparatively cheap raw materials to the manufacturers, they give them the means of perfecting the divisions of labor, and of supplying proportionably cheap manufactured goods, the latter are conveyed by their means, and at an extremely small expense, to the remotest part of the country. The direct advan-

tages they confer on agriculture are not less important. Without them, it would not be possible to carry to a distance sufficient supplies of lime, marl, shells, and other bulky and heavy articles necessary to give luxuriance to the crops of rich soils, and to render those that are poor productive. Good roads and canals, therefore, by furnishing the agriculturists with cheap, abundant supplies of manure, reduce, at one and the same time, the cost of producing the necessaries of life, and the cost of bringing them to market.

In other respects, the advantages resulting from improved communications are probably even more striking. They give the same common interest to every different part of the most widely extended empire; and put down, or rather prevent, any attempt at monopoly on the part of the dealers of particular districts, by bringing them into competition with those of all the others. Nothing in a state enjoying great facilities of communication is separate and unconnected. All is mutual, reciprocal, and dependent. Every man naturally gets into the precise situation that he is best fitted to fill; and each co-operating with every one else, contributes to the utmost of his power to extend the limits of production and civilization.

Such being the nature and vast extent of the advantages derived from trade, it is obviously the duty of legislatures to give it every proper encouragement and protection. The error of governments in matters of trade has not been in doing too little, but that they have done too much. The encouragement which has been afforded to the producers of certain species of articles in preference to others, has uniformly been productive of disadvantage. The encouragement which a prudent and enlightened government bestows on industry will equally be directed to remove everything that fetters the freedom of trade, or impedes the power of individuals to engage in different employments. All regulations, whatever be their object, that operate either to prevent the circulation of commodities from one part of a country to another, or the free circulation of labor, necessarily check the division of employments, and the spirit of competition and emulation, and must, in consequence, lessen the amount of produce. The same principle that prompts to open roads, to construct bridges and canals, ought to lead every people to erase from the statute book every regulation which either prevents or fetters the operations of the merchant, and the free disposal of capital or labor. Whether the freedom of internal trade and industry be interrupted by impassable mountains and swamps, or by oppressive tolls or restrictive regulations, the effect is equally pernicious.

The common law and ancient statutes of England, were decidedly hostile to monopolies, or to the granting of powers to any particular class of individuals to furnish the market with commodities. Lord Coke distinctly states, that all monopolies concerning trade and traffic,

are against the liberty and freedom granted by the great charter, and subsequent enactments. Few things occasioned more discontent in England, in the time of the Tudors, than the multiplication of monopolies; and notwithstanding the opposition made by the crown and the court party, in the reign of James I., the grievance became so intolerable as to give rise to the famous statute of 1624, by which all monopolies, grants, letters patent, and licenses for the sole purchasing, selling, and making of goods, and manufactures, not given by the act of the legislature, are declared to be "altogether contrary to the laws of the kingdom, void, and of none effect." This statute was productive of the greatest advantage, and perhaps contributed more than any other to the development of industry, and the accumulation of wealth. With the exception of the monopoly of printing Bibles, and the restraints imposed by the charters of bodies legally incorporated, the freedom of internal industry has ever since been vigilantly protected; and the Bible monopoly is now abolished, and the exclusive rights of corporations generally curtailed.

The same remarks apply to this country: the evils of restriction on trade were so keenly felt under the confederation that the state legislatures are prohibited by the constitution from laying any restriction on it by means of imposts or duties; and it may be said, that with the exception of patented and corporate rights, no restriction on the freedom of trade exists throughout the United States.

§ IV.—Commerce, or Foreign Trade.

What the home trade is to all the different provinces of the same country, foreign trade is to all the different countries of the world. Particular countries only produce particular commodities, and were it not for foreign commerce, they would be entirely destitute of all but such as are indigenous to their own soil. It is difficult for those who have not reflected on the subject, to imagine what a vast deduction would be made, not only from the comforts, but from the necessaries of every commercial people, were its intercourse with strangers to cease. It is not, perhaps, too much to say, that in the United States we owe to our intercourse with other countries one half or more of what we enjoy. We are not only indebted to commerce for supplies of linen, woollen, and silk goods, hardwares, the useful metals, tea, coffee, sugar, the precious metals, etc., but for our domestic animals, and most of the fruits and vegetables which we now cultivate, neither of which are indigenous to this country. Commerce both supplies us with an immense variety of most important articles, of which we must have otherwise been wholly ignorant, and it enables us to employ our industry in the mode in which it is sure to be most productive, and

reduces the price of almost every article. We do not waste our energies in raising beet-root for sugar, or in cultivating mulberry trees for silk, but we employ them in those departments of industry in which our circumstances enable us to produce goods more abundantly and cheaper than we can procure them from abroad; and we obtain the articles produced by foreigners more cheaply, in exchange for our surplus productions. We can thus avail ourselves of all the peculiar advantages and faculties of production, given by Providence to different countries. Thus we receive sugar from the West Indies, and send flour and salt meat in exchange; and from Britain we receive manufactured goods, and send cotton, grain, and lumber in return. It is impossible to point out a single country which is abundantly supplied with every commodity which its comforts or necessities require. Providence, by giving to each particular nation something which the others want, has evidently intended that they should be mutually dependent upon one another, and cultivate an amicable and friendly intercourse. It is not difficult to see, therefore, that those must be the richest and most abundantly supplied with every sort of useful and desirable accommodation, who cultivate the arts of peace with the greatest success, and deal with all the world on fair and liberal principles.

The commerce of one country with another is, to use the words of an able and profound writer, "merely an extension of that division of labor, by which so many benefits are conferred upon the human race." A country is rendered richer by its trade with another; its labor becomes infinitely more divided and more productive than it otherwise could have been. By a mutual exchange of all the accommodations which one country has, and another wants, the accommodations of both are multiplied; and they become more opulent and happy.

By this species of mutual intercourse, the various regions of the world are enabled to sort and distribute their labor, as most peculiarly suits the genius of each particular spot. The labor of the human race thus becomes much more productive, and every species of accommodation is afforded in much greater abundance. The same number of laborers, whose labors might have been expended in producing a very insignificant quantity of home-made productions, may thus produce a quantity of articles for exportation, accommodated to the wants of other places, and produced by it with peculiar facility. Thus the same amount of labor produces much more than if every country attempted to supply all its own wants.

What has been just stated is sufficient to expose the fallacy of the opinion that has sometimes been maintained, that whatever one nation may gain by her foreign commerce, must be lost by some one else.

Commerce is not directly productive, nor is the good derived from it to be estimated by its immediate effects. What commercial nations give, is uniformly the fair equivalent of what they get. In their dealings, they do not prey upon each other, but are benefited alike. The advantage of commerce consists in its enabling labor to be divided, and giving each nation the power of supplying themselves with the various articles for which they have a demand, at the lowest price required for their production, in those countries and places where they are raised with the greatest facility. The benefits resulting from an intercourse of this kind, are plainly mutual and reciprocal. Commerce gives no advantage to any one nation over another; but it increases the wealth and enjoyments of all, in a degree that could not have previously been conceived possible.

The influence of foreign commerce, in multiplying and cheapening conveniences and enjoyments, vast as it certainly is, does not equal the direct influence it exerts on industry, by adding immeasurably to the mass of desirable articles, by inspiring new tastes, and stimulating industry and invention by bringing each nation into competition with foreigners, and making them acquainted with their arts and institutions. The apathy and languor that exist in a rude state of society, have been universally remarked. But these uniformly give place to activity and enterprise, according as man is rendered familiar with new objects, and inspired with a desire to obtain them. An individual might, with considerable exertion, furnish himself with an abundant supply of the commodities essential to his subsistence; and, if he had no desire to obtain others, or if that desire, however strong, could not be gratified, it would be folly to suppose that he should be laborious, inventive, or enterprising. But, when once excited, the desires and wants of mankind become altogether illimitable; and to excite them, no more is necessary than to bring new products, and new modes of enjoyment, within his reach. Now the sure way to do this, is to give every facility to the most extensive intercourse with foreigners. The markets of a commercial nation, being filled with the various commodities of every country and every climate, the motives and gratifications which stimulate and reward the efforts of the industrious, are proportionally augmented. The husbandman and manufacturer exert themselves to increase their supplies of raw and manufactured produce, that they may exchange the surplus for the products imported from abroad. The merchant, finding a ready demand for such products, is prompted to import a great variety, to find out cheaper markets, and thus, constantly to afford new incentives to the enterprise and industry of his customers. The whole powers of the mind and body are thus called into action, and the passion for foreign commodities becomes one of the most efficient causes of wealth and civilization.

Not only, however, does foreign commerce excite industry, distribute the gifts of nature, and enable them to be turned to the best account, but it also distributes the gifts of science, and of art, and gives to each particular country the means of profiting by the inventions and discoveries of others, as much as by those of her own citizens. The ingenious machine, invented by Mr. Whitney, of the United States, for separating cotton wool from the pod, by reducing the cost of the raw material of one of the principal English manufactures, has been quite as advantageous to the English as to the Americans. The inventions and discoveries of Arkwright, Watt, and Wedgewood, by reducing the cost of articles sent abroad by Great Britain, have been as advantageous to foreign customers as to the English. Commerce has caused the blessings of civilization to be universally diffused, and the treasures of knowledge and science to be conveyed to the remotest corners. Its humanizing influence is, in this respect, most important; while, by making each country depend for the means of supplying a large portion of its wants, on the assistance of others, it has done more than anything else, to remove a host of the most baleful prejudices, and to make mankind regard each other as friends and brothers, and not as enemies. The dread, once so prevalent, of the progress of other nations, in wealth and civilization, is now universally admitted, by all intelligent persons, to be as absurd as it is illiberal. While every nation ought always to be prepared to resist and avenge any attack upon their independence, or their honor, it is not to be doubted that their real prosperity will be best secured, by their endeavoring to live in peace. A commercial war, whether crowned with victory, or branded with defeat, can never prevent another nation from becoming more industrious than we are; and, if they are more industrious, they will sell cheaper, and, consequently, our customers will forsake us, and go to them. This will happen, though we covered the ocean with our fleets, and the land with our armies. The soldier may lay waste, and the privateer make poor, but the eternal law of Providence will be fulfilled. *The diligent alone can make rich.*

Another advantage of industry and of refinements in the mechanical arts, is, that they produce refinements in the liberal arts; nor, can the one be carried to perfection, without being accompanied in some degree by the other. The same age which produces great philosophers and politicians, renowned generals and poets, usually abounds with skilful artificers. The spirit of the age affects all the arts; and the minds of men, being once roused from their lethargy and put into activity, turn themselves on all sides, and carry improvements into every art and science. Profound ignorance is totally banished: and men enjoy the privilege of rational creatures, to think as well as to act, to cultivate the pleasures of the mind, as well as those of the

body. The more these refined arts advance, the more sociable men become; nor is it possible, when men are enriched with science, and possessed of a fund of conversation, they should be content to remain in solitude, or live with their fellow-citizens in that distant manner, which is common among ignorant and barbarous nations. Both sexes meet in an easy and sociable manner, and the tempers of men, as well as their behavior, refine apace. So that, besides the improvements they receive from knowledge and the liberal arts, it is impossible but they must feel an increase of humanity from the habit of conversing together, and contributing to each other's entertainment. Thus industry, knowledge, and humanity, are linked together by an indissoluble chain. Most commercial treatises, and most books on political economy, contain lengthened statements as to the comparative advantages derived from the home and foreign trade. But these statements are mostly founded on erroneous principles. The quantity and value of the commodities which the inhabitants of an extensive country exchange with each other, is far greater than the quantity and value of those they exchange with foreigners. Commerce, it must be remembered, is not a direct, but an indirect source of wealth. The mere exchange of commodities adds nothing to the riches of society. The influence of commerce on wealth consists in its allowing employments to be separated, and prosecuted without interruption; in other words, in the division of labor, and the order, perfection, and abundance, or rather superabundance, arising out of the separate exercise of each branch of industry, and calling for an exchange of surplus production for foreign commodities. Commerce gives the means of pushing the division of labor to the fullest extent, and supplies mankind with an infinitely greater quantity of necessaries, and accommodations of all sorts, than could have been produced, had individuals and nations been forced to depend upon their own comparatively feeble efforts, for the supply of their wants. And hence, in estimating the comparative advantageousness of home and foreign trades, the real questions to be decided are, which of them contributes most to the division of labor? and which of them gives the greatest stimulus to inventions and industry? These questions do not admit of a very satisfactory answer. The truth is, that both home trade, and foreign trade, are most prolific sources of wealth. Without the former, no division of labor could be established; and man would forever remain in a barbarous state. Hence, perhaps, we may say that home trade is the most indispensable, but the length to which it could carry any particular country, in the career of civilization, would be limited indeed. Had Great Britain, for example, been cut off from all intercourse with foreigners, there is no reason to think that she would at this day have been advanced beyond the point to which

her inhabitants had attained during the heptarchy. It is to the products and the arts derived from others; and to the emulation inspired by their competition and example, that she is mainly indebted for the entraordinary progress she has made, and the station she now occupies.

§ V.—Taxation.

Taxation denotes that part of their property which the government of a state exacts for the supply of the public necessities, from its subjects or other persons residing in the country, and partaking of its advantages. Hence they form a part of the public revenues. Another part is formed by the proceeds of public property, either rent or selling price.

In most states, particularly in those of the middle ages, public expenditures were supplied from the revenues of domains. As the expenses of the state continually increased, or the rulers, from bad economy, found the above-mentioned sources of revenue insufficient, they began to demand contributions from the members of the community, and imposed upon them taxes or imposts. They usually, however, met with great difficulties, since the nobles would not suffer themselves to be taxed, under pretext of forming a state within themselves, and maintained that such contributions could be raised only with their consent. What could be obtained from them by contribution was very little. They acknowledged the necessity of increasing the revenue of the state, but the sovereigns were afraid to constrain them to contribute, and inclined to grant them exemption from taxes, if they would only consent that the rest of the nation, which did not belong to their privileged order, should be subject to imposts. The nobles, fearing that if no other source of revenue were left open to the sovereign, the burden of taxes would fall upon themselves, willingly allowed the sovereign the right of taxing the nation, which, from want of union and power, was obliged to yield. Thus, the taxes, for a long time, were laid almost everywhere on the commons only, the higher and most powerful orders, the clergy and nobility, being exempt.

Enlightened governments, however, early perceived that in order to render taxes a permanent source of revenue, means must be left to the subjects of gaining every year so much as to be able to subsist, and to have a sufficient sum left to pay the taxes. Hence, they were induced to refrain from exhausting their property. But a long time elapsed before the principles of equitable taxation were well understood. It was not till a late period, when government became an object of profound reflection, and a more perfect system of politi-

cal economy arose, that a theory of taxation was formed which could be used as a solid basis of revenue. According to this theory, taxes are portions of the property of individuals, which each has to contribute to the public treasury, to defray the public expenses. From this definition, it follows, 1st. That no one should be exempted from taxes who possesses property or income, and is protected in his person and estate, and that, in consequence, absolute freedom from taxes in any individual so situated, is unjust towards those members of the community who are charged with them. 2d. That the taxes ought to be assessed according to the net income of each individual. 3d. That the taxes must never be suffered to injure the sources of income. 4th. That the ratio of taxes to income, ought to be as small as possible, in order that the revenue of the nation, as well as of the individual, may be allowed to increase. The greatest difficulty in effecting a just distribution of taxes, is to find the clear income of every individual. In the modes of taxation anciently practised, this difficulty was but little considered. Financiers were satisfied with laying taxes where they observed property, or income, without caring much whether they were taken from the gross or net income, from the capital or from the interest and profits. The rudest mode was to assess the taxes according to the number of heads. On the supposition that every one received enough to pay something, they demanded from every head such a sum as it was supposed even the poorest could afford; the rich and the poor paid the same amount; and, therefore, the greatest inequality prevailed. Real property was early taken as a standard in distributing the taxes, as cultivated land, in civilized countries, appeared to be the safest and most substantial property. As this afforded to its proprietors or cultivators a certain income, the annual produce of the land was estimated, and taxed accordingly. Thus arose the land tax, in which, however, the gross and net produce of the lands were seldom accurately distinguished; and where it was done, little dependence was to be placed upon the estimate itself, and still less on the maintenance of this principle through the changes of income. As the land tax was insufficient to furnish the necessary revenue, other means were sought for, and the closest attention was paid to all those quarters where money appeared. Wherever money changed hands, as in sales, exchanges, or inheritances, taxes were laid. Whoever desired to obtain any favor from the public officers, was obliged to purchase it with money. When property was acquired, something must be relinquished. Hence, the long series of taxes on acquisition and industry. As the income of the members of the community did not yield so much as the state required, the attention of governments was directed to expenditures; and people were made to pay wherever their expenses could be estimated. Thus, taxes on consumption of

every description were established. When taxes began to be treated scientifically, which was not till a long time after the different kinds had been invented and introduced, attempts were made to bring the whole mass of the existing taxes under a general system.

In order to judge whether taxes are rightly distributed, it must first be considered whether or not they can be paid regularly and continually from the net income. There may be a possession which brings no gain at all, as a library, a collection of pictures, etc. If an annual tax is laid upon such property, it would sooner or later consume the property, if it were to be paid from it, and consequently contradict the principles above laid down, that property should be taxed only so far as it affords a regular income.

In like manner, acquisitions can rightly be taxed only when they are a permanent source of gain. If, therefore, any one acquires an estate or capital, by purchase, exchange, etc., and taxes are laid upon such an acquisition, the tax is taken from the capital, that is, from the means destined to produce profit. As far as this happens, or is in danger of happening, the system of taxation is defective. If, in fine, a tax is laid on enjoyment, or the value of things enjoyed, this can be justified only so far as he who purchases, or enjoys such things, can afford the expense from an income which furnishes, or ought to furnish, more than enough for his subsistence, and the source of which is not necessarily diminished by the tax. If we seek, therefore, for the principle of the distribution of taxes which ought to serve, at the same time, as a rule for judging of the propriety of the distribution, this can be no other than the net income of the persons, or the net produce of the property, when duly cultivated or improved. If one leaves unproductive, property which could well be rendered productive, his indolence, pride, or negligence should not of course except him from taxation.

Net income, or net profit, is that part of income, or profit, which remains after the portion necessary for the maintenance of the person, or the continuance of the property which produced the income or the profit, has been subtracted. Income and profit are produced either from land, from capital, or from labor. All taxes will be just and useful, only so far as they are a part of the net produce from these sources, and are imposed and distributed upon this principle. But, as it is difficult, and, in some cases, impossible in practice, to ascertain the net revenue of every one, the politician must take different ways to find out the just proportion. The first way is *direct*, viz.: to determine from the statement of the parties concerned, or from official estimation, the net income of the persons, or the net produce of the land, and to assess the taxes according to the result. This kind of taxes is called direct. But as they leave a large portion of net incomes doubtful, their amount is sought for indirectly. It is

supposed, that he who receives more than the amount at which he has rated his income, will consume and enjoy more than this sum will warrant; and, in particular, that he will enjoy certain articles, which the man of smaller income consumes not at all, or in smaller measure. If, then, the expense for articles of consumption is taxed, an additional sum can be generally drawn from all those who pay already a direct tax on income, not sufficient to cover the expenses of the state. This sum they can pay from their direct income, if their affairs are well arranged. In this way something more is obtained from the net income of those who have concealed a part, and would otherwise have been taxed according to their own statement. These taxes are termed *indirect*, as they are not calculated on the income, but in an indirect manner. The art of reaching this net income, by taxes on consumption, or other indirect taxes, is very imperfect. Its perfection, however, is necessary, if the system of taxation is to be established on just principles.

By direct taxes, then, are understood such as are laid immediately on the real payers; by indirect taxes, such as are assessed on others in advance, who are left to remunerate themselves from the rest of the community. But the same principle does not afford a logically correct division; for the same tax can be raised, at one time directly, at another indirectly. Thus all taxes of consumption may be raised as well from those who consume the articles, as from the tradesmen who deal in them. In like manner, many articles of luxury are taxed directly. Nevertheless, the taxes remain indirect, because the net income is taxed only according to the extravagance of individuals.

Taxes imposed on goods at the time of their importation, are denominated *customs*, *duties*, or *imposts*. Adam Smith mentions one objection to this mode of raising revenue—that the importing merchant must enhance the price of his goods, not only by the amount of duty advanced by him, but also for interest, profit, and guarantee of that amount, so that the consumer must, in fact, pay more than the tax. This objection is avoided by an *excise* tax, which is levied on the goods in the hands of the person who uses them, or at the time of their coming into his hands. An annual excise is sometimes levied upon articles of a durable nature, such as carriages, watches, &c., and the principle upon which this is apportioned, is to graduate according to the supposed expenditure of the persons paying the tax, assuming that this will be nearly in proportion to their income. With respect to imported articles, the excise is either a substitute for customs, or an addition to them. Considered as a substitute, the excise avoids the objection pointed out by Adam Smith; but then it is an expensive tax to collect, and it necessarily gives rise to an irksome inquiry into the private concerns and habits of people, so that, as far as imported goods are the subject of taxation, the customs are

the most convenient, and on the whole, the most productive tax; and this mode of taxing is almost universally adopted in preference, both in Europe and in the United States.

It cannot be made a question among a free people, to whom the right of taxation belongs. In England, the principle has long been acknowledged, that taxes are a voluntary donation from the people to the government. On the European continent, where, in the course of time, nearly all national representation has been lost, the physical power of the government is the sufficient argument, as in so many other instances, by which all discussion on the right of taxation is made useless. The theory of taxes has been but very lately illustrated and perfected. Adam Smith laid the first foundation of a complete theory, towards the end of the last century. It is well known that a dispute regarding the right of the mother country to levy taxes on her colonies, caused the American revolution, and led to the independence of the United States. The colonists took the ground that *taxation, without representation, is oppression;* and they have always acted on that principle.

The privilege of exemption from taxes is granted to some orders of society, to individuals, or to particular kinds of property. The reasons for which this exemption is usually allowed are as follows:— 1st. The identity of the person exempted with the state; 2d. To reward services rendered to the state; 3d. As a means of paying debts, due from the state; 4th. The incompatibility of the public burdens with the office or character of the individual exempted; 5th. Because the equivalent is received in some other way; 6th. Poverty; 7th. Ancient privileges. These exemptions originated in a period of limited views.

It is only in France, Britain, and the United States, that anything like a just system of taxation is attempted: and even in these countries, it may be said to be attempted rather than effected. In all other countries, part sometimes arises from public domains; but most is raised by excessive imposts or duties, and not a little frequently by forced contributions. Thus in Turkey it was customary, until lately, for the pachas to fleece any person within their provinces who had money, and for the sultan to have the pacha, who had accumulated wealth, strangled, and then seize his treasures.

§ VI.—Banks and Banking.

The term *bank*, in reference to commerce, implies a place of deposit of money. Banks are establishments intended to serve for the safe custody of money, for facilitating its payment by one individual to another, and for the accommodation of the public with loans.

Banks, like most commercial institutions, originated in Italy, where, in the infancy of European commerce, the Jews were wont to assemble in the market-places of the principal towns, seated on benches, ready to lend money; and the term bank is derived from the Italian word *banco*, or bench, from the benches on which the Jews sat, to transact the business of money-lending. Banks are of three kinds, viz., of *deposit*, of *discount*, and of *circulation*, or *issue*. In many cases, all these functions are exercised by the same establishment; sometimes, only two of them, and in other cases, though rarely, one.

A bank of deposit receives money to keep for the depositor until he draws it out. This is the first and most obvious purpose of these institutions. The goldsmiths of London were formerly bankers of this description. They took the money, bullion, plate, &c., of depositors, merely for safe keeping. Another branch of banking business is the discounting of promissory notes and bills of exchange; or, loaning money upon mortgage, security, or pawn, &c. A bank of circulation issues bills or notes of its own, intended to be the circulating currency, or medium of exchanges, instead of gold and silver. Banks are also divided into public and private; but what is a public bank is not very definitely settled. Where the supreme power of the nation, or the municipal authorities of a place, as in Amsterdam, have the direct management of a bank, it is a public one; and so are those institutions whose credit is connected with that of the government, or which are used as instruments in collecting and distributing the public revenues. Those also are usually considered public banks, which are carried on under a charter from the supreme power; whereas a private bank is usually understood to be one that is carried on by one or more individuals, without any particular connection with the government, or any special authority or charter. Thus there is, in England, but one public bank, the bank of England—whereas, in the United States, most of the banks are public, and in some of the states, private banks of circulation are forbidden by law. The bank of England is the principal bank of circulation in that country; but it is also a bank of deposit. The bank of France holds a similar position in that country.

The establishment of banks has contributed, in no ordinary degree, to give security and facility to all sorts of commercial transactions. They afford safe and convenient places of deposit for the money that would otherwise have to be kept, at a considerable risk, in private houses. They also prevent, in a great measure, the necessity of carrying money from place to place, to make payments, and enable these to be made, in the most convenient, and least expensive manner. A merchant, for instance, or tradesman, who

employs a banker, keeps but very little money in his own hands, making all his considerable payments by drafts, or checks, on his banker; and he also sends the various checks, bills, or drafts, payable to himself, to his bankers, before they become due. By this means he saves the trouble and inconvenience of counting sums of money, and avoids the losses to which he would otherwise be liable from receiving bad or uncurrent money, besides the trouble which frequently attends the presentation of bills. A merchant can also refer to his bankers as vouchers for his respectability, and in case of desiring information respecting the credit or pecuniary circumstances of any individual, his bankers will best acquaint him with facts, as they make it their business to know the condition of those who have dealings with banks.

Banks generally charge no commission on the payments made and received on account of those who deal with them: but they allow no interest on the sums deposited with them, and it is either stipulated or distinctly understood, that a person employing a banker, should, besides furnishing him with sufficient funds to pay his drafts, keep an average balance in the banker's hands, varying, of course, with the amount of business done on his account; that is, according to the number of his checks, or drafts to be paid, and the number of drafts and bills to be received for him. The bankers then calculate, as well as they can, the probable amount of cash it will be necessary for them to keep in their coffers, to meet the ordinary demands of customers; and employ the balance in discounting mercantile bills, purchasing government securities, or in some other profitable adventure. So that their profits result, in case of their not issuing notes, from the difference between the various expenses attendant on the management of their establishment, and the profits derived from such parts of the sums lodged in their hands, as they can venture to employ in an advantageous way.

Banks, as a general rule, do not allow any individual to overdraw his account. They answer drafts to the full extent of the funds deposited in their hands; but they will not pay a draft if it exceed that amount. Sometimes, however, a person gives them security to a certain amount, and he can draw for any amount not exceeding that sum, whether he has any money on deposit or not. The usual method of obtaining money from a bank when one has nothing deposited, is to give his note to the bank, with an endorser as security, for the sum he draws, and the interest in addition.

The facility which banks afford to the public in the negotiation of bills of exchange, or in the making of payments at distant places, is very great. Many banks have a direct intercourse with others at a distance. Hence, an individual residing in any part of the country, who wishes to make a payment at a distant point, may effect his

object by applying to the bank nearest to him. Thus, suppose A, of New York, has a payment to make to B, of New Orleans: to send the money by post would be hazardous; and if there were high fractional parts of a dollar in the sum, it would be inconvenient to make use of the post. How will A manage? He will pay the sum to a banker in New York, and his creditor in New Orleans will receive it from a banker there. The transaction is extremely simple. The New York banker merely gives A a check on the corresponding bank in New Orleans, requesting them to pay the amount to B. A forwards the check to B, who accordingly delivers it to the bank, and receives the amount. The New York bank may probably inform their correspondents that they have drawn on them for such an amount, payable to such a person, etc. A small per centage charged by the New York banker, and the postage, constitutes the whole expense. There is no risk whatever, and the whole affair is transacted in the cheapest and most commodious manner. A large proportion of inland bills made in the regions adjacent, and also foreign bills drawn upon a person residing in a certain section of country, are made payable in some neighboring city. London, Paris, Amsterdam, and Hamburg, are the great centres of bill transactions in Europe; and New York and New Orleans, in the United States.

In consequence of these and other facilities afforded by the invention of bankers, for the settlement of pecuniary transactions, the money required to conduct the business of an extensive country, is reduced to a mere trifle, compared with what it otherwise would be. It is not possible to form an accurate estimate of the total saving thus effected. But supposing that 100 or 150 millions of dollars of specie and bank notes are at present required in money transactions for the circulation of the United States, it may be fairly concluded that 500 millions would have been necessary to transact an equal amount of business but for these devices. This statement strikingly exhibits the importance of banking, in a public point of view. For by its means, 100 or 150 millions are rendered capable of performing the same functions, and in a much more commodious manner, that would otherwise have required four times that sum: and supposing that 40 or 50 millions are employed by the banks as a capital in their establishments, no less than 60 or 100 millions will be entirely disengaged, or cease to be employed as an instrument of circulation, and made valuable for employment in agriculture, manufactures, and commerce.

Not only does the formation of banking establishments enable the business of a country to be conducted with a far less amount of money, but it also enables a large portion of that less amount to be fabricated of the least valuable materials, or of paper instead of gold. The mode in which this substitution originally took place,

naturally grew out of the progress of society. When governments became sufficiently powerful and intelligent to enforce the observance of contracts, individuals possessed of written promises from others, that they would pay certain sums at specified periods, began to assign them to those to whom they were indebted; and when those by whom such obligations are subscribed are persons of whose solvency no doubt can be entertained, they are readily accepted in payment of the debts due by one individual to another. But when the circulation of obligations or bills in this way has continued for a while, individuals begin to perceive that they may derive a profit by issuing them in such a form as to fit them for being readily used as a substitute for money, in the ordinary transactions of life. Hence the origin of bank notes.

An individual in whose wealth and discretion the public have confidence, being applied to for a loan of 5,000 dollars, grants the applicant his bill or note, payable on demand, for that sum. Now as this note passes, (in consequence of the confidence placed in the issuer), currently from hand to hand, as cash, it is quite as useful to the borrower, as if he had obtained an equivalent amount of gold. And, supposing that the amount of interest is 6 per cent., it will yield, so long as it continues to circulate, a revenue of $300 per annum to the issuer. A banker who issues notes, coins as it were his credit. He derives the same revenue from the loan of his written promise, to pay a certain sum that he would derive from the loan of the sum itself; and, while he thus increases his own income, he also increases the wealth of society. Besides being incomparably cheaper, bank notes are incomparably more commodious than a metal currency. A bank note for $100, or $1000, may be carried about with as much facility, as a single quarter dollar. It is of importance also to observe that its loss is only the destruction of so much paper. No doubt it might be a serious calamity to the holder; but to whatever extent it injured him, it would proportionally benefit the issuer, whereas the loss of coin is an injury to the holder, without being of service to any one else; it is, in fact, so much abstracted from the wealth of the community.

Promissory notes, issued by private individuals or associations, circulate only because those who accept them have full confidence in the credit and solvency of the issuers, or because they feel assured they will be paid when they become due. If any circumstances transpired to excite suspicions as to their credit, it would be impossible for them to circulate any additional notes, and those that they had issued would be immediately returned for payment. Such is not the case with paper money, or with notes that are declared legal tender. It is not necessary, in order to sustain the value of such notes, that they should be payable at all. The only thing required

is that they should be issued in limited quantities. Every country has a certain number of exchanges to make; and whether these are effected by the employment of a given number of coins, of a particular denomination, or by the employment of the same number of notes of the same kind, is of no importance. Notes which have been made legal tender may be regarded as a sort of tickets, or counters, to be used in computing the value of property, and in transferring it from one individual to another; and they circulate, because having been selected to perform the functions of money, they are as such readily received by individuals in payment of their debts. As they are in no wise affected by fluctuations of credit, their value must depend entirely upon the quantity of them in circulation, as compared with the payments to be made through their instrumentality, or the business they have to perform. By reducing the value of notes below the supply of coins that would circulate in their place, were they withdrawn, their value is raised above the value of gold; while, by increasing them to a greater extent, their value is lowered proportionally. In order to prevent the over-issue of paper, it is necessary to enact a law that all notes should be payable on demand, and to prohibit any one from issuing notes, until he has given full proof that he is able to pay them. It is now admitted by all to be indispensable, in order to prevent injurious fluctuations in the value of money, that all notes be made payable at the pleasure of the holder, in an unvarying quantity of gold and silver. This renders it impossible that the issuers of paper should depreciate its value below that of the precious metals. They may, indeed, by over-issuing paper, depress the value of the whole currency, gold, as well as paper, in the country where the over-issue is made, but the moment they do this, gold begins to be sent abroad; and paper, being returned upon the issuers for payment, they are obliged, in order to avoid exhausting their coffers, to lessen their issues, and thus, by raising the value of the currency, stop the drain for specie.

The circumstances that excite public confidence in the issuers of paper are extremely deceitful: and innumerable instances have occurred of the population of extensive districts having suffered severely from the insolvency of bankers in whom they placed the utmost confidence. In 1793, in 1814, in 1815, and in 1825, a very large proportion of the banks in England were destroyed, and produced by their fall an extent of ruin hardly equalled in any other country. Similar results happened in the United States in 1825 and in 1837. It is no exaggeration to affirm that countries sustain ten times more injury from the circulation of worthless paper, or paper issued by persons who have no means of redeeming it than from the issue of counterfeit coin and forged notes. Laborers,

women, minors, and other persons incapable of judging of banking establishments, are, nevertheless, dealers in money, and liable to be imposed upon. It is therefore the duty of legislatures to protect the interests of those who cannot protect themselves, by compelling all persons who issue notes to give sufficient security for redeeming them, before the notes are issued. A security of this sort has been exacted by the British parliament, in the case of the bank of England, and the twelve millions of pounds due to the bank by government, from the nation, must be sacrificed before the holders of its notes can sustain the smallest loss. The stability of the bank of England may, therefore, be said to be equal to that of the British government. The system of taking securities has been found to answer so well, wherever it has been adopted, that the practice is rapidly extending, so that we may in future expect to escape the calamities of former years. Proper securities will render the ultimate failure of banks of issue impossible; and a degree of solidity will thus be imparted to money operations, which can never be realized where banks are allowed to issue notes to any extent they please, without caring whether they have any sufficient means to redeem them or not.

§ VII.—Specie Currency.

Coins, or specie currency, are pieces of metal—most commonly gold, silver, or copper—impressed with a public stamp, and generally made legal tender, in payment of debts, either to a limited or an unlimited extent.

When the precious metals first began to be used as money, or as standards by which to measure the value of various articles, and the equivalents for which they are most commonly exchanged, they were in the shape of bars, or ingots, of no particular weight. The parties, having agreed upon the quantity of metal to be given for a commodity, ascertained the exact amount by weighing the bars. But it is obvious that a plan of this sort must have been attended with a great deal of trouble and inconvenience. The greatest obstacle, however, to the use of unfashioned metals as money, was found in the difficulty of determining their quality, or the degree of their purity, with sufficient precision. The operation of assaying is one of great nicety and difficulty, and could not be performed in the early ages, otherwise than in a clumsy, tedious, and inaccurate manner. It is, indeed, most probable that when the precious metals were first used as money, their quality would be appreciated only by their weight and color. A very short experience, however, would be sufficient to show that such unsatisfactory tests were exceedingly inaccurate in their

conclusions. It was soon discovered, that in order to ascertain the purity of gold, and to avoid the trouble and expense of weighing it, nothing more was necessary than to mark each piece with a stamp declaring its weight and fineness. This invention was made at a very early period. According to Herodotus, the Lydians were the first that coined money.

Before the art of Metallurgy was well understood, the baser metals were often used as money. Iron was the primitive money of the Lacedemonians, and copper of the Romans. But both iron and copper deteriorate by being kept; and, besides this defect, the rapid improvement of the arts, by lowering their price, rendered their bulk too great in proportion to their value, to permit of their continuing to be used as money. Copper, indeed, still is used, but only in very small payments. In England, copper coins are rated 72 per cent above their real value; but, as their issue is exclusively in the hands of government, and as they are legal tender only to the extent of one shilling in any one payment, this over-valuation is not productive of any bad effect. The use of copper, in other countries, is limited in much the same way; gold and silver being everywhere the only metals used in the manufacture of the coins employed in considerable payments.

§ VIII.—Standard of Coins.

By the standard of coins, is meant the degree of its purity and its weight; that is, the fineness of the metal of which it is made, and the quantity of metal contained in it.

The purity of gold is not estimated by the weights commonly in use, but by an Abyssinian weight, called a *carat.* The carats are subdivided into four parts, called *grains:* and these again, into quarters; so that a carat grain, with respect to the common divisions of a pound Troy, is equivalent to 2½ dwts. Gold of the highest degree of fineness, or purity, is said to be 24 carats fine. The gold is always supposed to be divided into 24 equal parts; and the number of these which are gold, is indicated by the carats. Thus, "gold 18 carats fine," means gold which contains 18 grains of pure gold, for every 6 of alloy, or gold of which one fourth is alloy.

When gold coins were first made at the mint, in England, the standard of the gold put in them was 23 carats 3½ grains fine, and ½ grain alloy, and so it continued without any variation to Henry VIII., who, in the eighteenth year of his reign, introduced a new standard of gold, of 22 carats fine, and 2 carats alloy. The first of these standards is called the old, and the second the new standard, or crown gold; because crowns, or pieces of the value of five shillings, were first coined of this new standard. Henry VIII. made his gold

coins of both these standards, under different denominations; and this practice was continued till 1633. From that period till the present moment, the gold of which the British coins have been made, has been invariably of the new standard, or crown gold; though some of the coins made of the old standard, continued to circulate till 1732, when they were forbidden to be any longer current. The purity of the present gold and silver coins of England, is eleven parts of pure metal, and one part alloy, or one twelfth of the whole weight of alloy. The French and United States coinage contains one tenth of alloy. In technical phraseology, the latter coins are 21.6 carats fine, and the English coins are 22 carats fine. The United States eagle, at present, weighs 258 grains, and the dollar 412.5 grains, and the halves and quarters in proportion. Our old coinage was heavier, and contained rather less alloy.

The alloy in coins is reckoned of no value. It is allowed, partly in order to save the trouble and expense that would be incurred in refining the metals so as to bring them to the highest degree of purity; and partly because, when its quantity is small, it has a tendency to render the coins harder, and less liable to be worn or rubbed. If the quantity of alloy were great, it would lessen the splendor and ductility of the metals, and would add too much to the weight of the coins.

§ IX.—Colonies and Colonial Policy.

The term *Colony*, is defined by Dr. Johnson, "a body of people drawn from the mother country, to inhabit some distant place." But something more is necessary to complete the definition than the idea of inhabiting a distant place; for the mere inhabiting of another country would not constitute them a colony. It seems necessary that they should not live under the authority of any foreign government, but either remain under the government of the mother country, or exist under a government of their own. Of colonies remaining under the government of the mother country, the West India Islands, subject to the different European states, afford an example. Of those existing under a government of their own, the most celebrated example is found in the colonies of the ancient states of Greece. The United States of America constituted an example of colonies of the first sort, before the revolution, which separated them from the mother country; and now they may be regarded as constituting an example of colonies of the Grecian sort, as they exist under a government of their own.

Again, the term colony is sometimes employed in a sense in which the idea of a body of people, drawn from a mother country, hardly

seems to be included. Thus, we talk of the British Colonies in the east, meaning the East Indies. Yet, it can hardly be said, that any body of people is drawn from the mother country to inhabit the East Indies. The only European people there, are a small number of persons who are sent to hold possession of a foreign and conquered country; and, in this sense, all the conquered provinces of the ancient Roman Empire, might be called what they never have been called—Colonies of Rome. In the meaning of the term "colony," the predominant idea among the ancient Greeks and Romans, appears to have been that of the people—the emigration of a body of people to a new and permanent abode. The predominant idea among the moderns, respecting the term "colony," appears to be the possession of a territory, lying out of the country; and almost any outlying territory, continuing in possession, would receive the name of a colony.

If we use the term with so much latitude as to embrace the predominating idea both of ancients and moderns, we shall say that a colony means an outlying part of the population of the mother country, or an outlying territory belonging to it, either both in conjunction, or one of the two by itself.

Some of the British colonies are of the sort in which the predominating idea is that of the people who constitute it, or an idea of population, resembling the Roman and Grecian colonies. There is nothing in modern times which so much resembles the colonization of Asia Minor by the Greeks, as the colonization of New England by the English. Of the first English settlers a large proportion went out to escape the oppression of a predominating religion, as the Greeks did to escape the oppression of a predominating political party. One difference was, that the English did not go off at once, in considerable bodies, under distinguished leaders, or with a large capital to provide for future prosperity. Accordingly, the prosperity of the New England colonies was much less rapid, and much less brilliant than that of the Grecian colonies of which we speak. Another great difference was, that the Grecian colonies were independent; but the English colonies, though they made a sort of subordinate government for themselves, were still held subject to the government of the mother country.

A population is said to be redundant, not when it is numerically either great or small, but when it is too great for the quantity of the necessaries of life, so that the population exceeds its resources for maintenance.

Any one country produces, or procures a certain quantity of those necessaries in the year. If it has a population greater than such a quantity is sufficient to support, all that number which is over and above what it is capable of maintaining, is a redundancy of popula-

tion. When we say that where the supply of necessaries has become too small for the population, the great body of the people take less wages for their labor, we mean that they take less than is requisite for their comfortable subsistence, because they would only have what was requisite for that purpose when the supply of necessaries was not too small for the whole.

The effect of a disproportion between the necessaries of life and the population, is not to supply to the full measure, that portion which they are sufficient to supply, and to leave the redundant portion destitute: it is to take a portion of his due quantity from every individual of that great class who have nothing to give for them but manual labor.

What this state of things imports, is most easily seen. The great class just mentioned, are the great body of the people. When every individual of that body has less than his due quantity of necessaries, less than his share, if the quantity were not too small for the population—the people at large must be in a state of painful and degrading poverty. They are wretchedly fed, wretchedly clothed, and live in wretched houses; and they have neither time nor means to keep their houses or their persons free from repulsive and pestiferous impurities. Those of them who, either from bodily infirmities have less than the ordinary quantity of labor to bestow, or from the state of their families need a greater than the ordinary quantity of necessaries, are condemned to starve—either wholly, if they have not enough to sustain life at all, or partially, if they have only enough to yield them a lingering, diseased, and shortened existence.

What the ignorant and unthinking spectator sees in this, is not a redundant, but only a poor population. He sees nobody without necessaries who has enough to give for them; to his eye, therefore, it is not the necessaries of life which are wanting, but that which is to be given for them.

In countries newly inhabited, or in which there is a small number of people, there is generally a quantity of land yielding a large produce for a given portion of labor. So long as the land continues to yield in this liberal manner, however fast population increases, food and other necessaries may increase with equal rapidity, and plenty remain. When population has increased to a certain extent, all the best land is occupied; if it increases any farther, land of a worse quality must be taken in hand. When land of the next best quality is all exhausted, land of a still inferior quality must be employed, till at last you come to that which is exceedingly barren. In this progress, it is very evident that it is always gradually becoming more and more difficult to make the necessaries of life increase with any given degree of rapidity, and that you must come at last to a point where it is altogether impossible.

There can be no doubt, that by employing a greater proportion of people in cultivating the land every ensuing year, a greater quantity of necessaries would be produced: in this way it would be possible to go on increasing the food in quantity, as fast as the population increased. The result, however, would be this: that as the land yields gradually less and less to every new portion of labor, it would be necessary to employ, not only a greater number of people as laborers, but a greater and greater proportion of the body of the people in raising necessaries; and the larger this proportion, the smaller the number of people employed in producing comforts or conveniences. We could, therefore, increase the quantity of necessaries to meet the demands of the population, only by diminishing the supply of those other things which minister to human desires. Suppose the average number of children in a family to be five, and that the father's labor was all required to produce the bare necessaries of life, there would be nothing for comfort, elegance, or ease. There would be no class exempt from the necessity of perpetual labor, by whom knowledge might be cultivated, and discoveries made. There would be no legislators, nor physicians. The human race would become a mere multitude of animals.

When the population of a country is full, and it cannot increase without producing the evils of redundancy, a portion of the people, sent off to another country, may create a void; and till this is filled up, population may advance as rapidly as before, and so on, for any number of times. So long as the earth is not peopled to that state of fulness, which is most conducive to human happiness, this resource is the best scheme for diminishing the rate of population. It is highly desirable, on many accounts, that every portion of the earth, which is adapted to the well-being of humanity, should be inhabited as fully as the conditions of human happiness admit. It is only in certain circumstances, however, that a body of people can be advantageously removed from one country, for the purpose of colonizing another. In the first place, it is necessary that the land they are about to occupy, should be capable of yielding a greater return for their labor than the land they leave; otherwise, though relief is afforded to the land they leave behind, their own circumstances would be no better than they would have been had they remained. Another condition is, that the expense of removal from the mother country to the colony should not be too great. If the case be so, the population which remains behind may suffer more by the loss of capital than it gains by the diminution of its numbers. A certain portion of capital is necessary to give sufficient employment: but if, to afford the expense of removal, so much is taken from that capital that the remainder is not sufficient for the

remaining population, there is still in that case a redundancy of population, and all the evils which it brings.

The idea of a colony for the sake of getting rid of delinquents, if not peculiar to English policy, is a more remarkable part of the policy of England than of any other country. In dealing with a delinquent population, the object aimed at, the security of the non-delinquent or virtuous part of the community, embraces two particulars—security from the crimes of this or that individual delinquent, and security from the crimes of many others, who may be tempted to follow his example. And the question arises, whether transporting a delinquent to a foreign land, and subjecting him to certain privations, laws, and penalties, under the arm of government, can be effectual in securing those two great objects. We shall see that it never can secure either. The mere banishment of the delinquent to another country cannot secure his reformation; and his offences will still affect all who come in contact, either with him, or those whom his example corrupts. Moreover, a very great proportion of those who are banished, will find the means of returning; and those who do so, will be found to have become only more dexterous in crime, by their travels. Their associates' banishment can have no influence whatever in restraining those who are left behind, because they never see them; and when they think of them, they will be apt to consider them gainers, rather than losers, by the change of place. The plan of penal colonies therefore has been, and ever will be, ineligible: such colonies have been of no benefit whatever to England; and the United States wisely avoided any such scheme. They take means to reform and punish delinquents, where they have committed crimes, instead of sending them to parts where reformation and the benefit of witnessing their punishment are equally hopeless. As penal settlements, therefore, colonies are worse than useless.

If it be inquired, what reasons can any country have for desiring to possess the government of such territories? we answer, there are two ways in which advantage might possibly accrue to the mother country: 1st. The colonies might yield a tribute; or, 2d. They might yield an advantageous trade.

With respect to tribute, the plan of forcing their free descendants to pay what is generally exacted only from conquered countries, is too absurd to be entertained. It could not be enforced in ancient times. Much less will it ever be submitted to in the present day.

Those taxes which were vainly and unjustly attempted to be imposed upon the former English colonies of North America, were never dreamed of as a tribute, and never spoken of, except in a sense contrary to that of a tribute, namely, that of reimbursing to the mother country a part, and no more than a part, of that ex-

pense which they cost her in governing and defending them. With regard to the East Indian colonies of Britain, so far are they from yielding tribute, that in loans, aids, and the expense of fleets and armies, they have cost enormous sums of money; and their government has always been in debt. But the trade of those dependencies is supposed to be the great advantage which has been ascribed to what is called "The British Empire in the East." The advantage derived from this trade consists in monopoly. If the trade of those colonies were free, other nations would derive as much advantage from it as the mother country, and the mother country would derive as much advantage from it, if the colony were independent.

We will now inquire, what is the value of that advantage gained by monopoly from the trade of a colony. It is very evident, that whatever the mother country gains, the colony loses. If the colony were part of the dominions of a foreign state, there are circumstances in which that result would be desirable. But suppose the colony is a part of the same state, or of the same country, how is the result to be viewed? Is it not precisely the same sort of policy, as if New Hampshire were to be drained and oppressed for the sake of New York? Does the wealth of a state consist in the wealth of one part, effected by the misery of another? What should we think of such a rule for guiding the policy of a state? This would be a contrivance for diminishing her wealth and happiness. For when from one of two parties, equally provided with all the means of enjoyment, you take a portion to give to the other, the fact is, that you add nothing to the happiness of the one, and you diminish that of the other. This is, in truth, the foundation upon which the laws for the protection of property rest. As the happiness of one man is as dear to the country as the happiness of another, if the man who takes from another a part of his property, added to his own as much as he took from the happiness of the other, there would be no loss on the whole; and the state would have no ground, in utility, on which to interfere.

But this is not all. Not only is the quantity of happiness diminished upon the whole, but by that operation which gives the mother country an advantage by the trade of the colony, the quantity of produce of the community is diminished upon the whole. The subjects of the state, taken as a whole, not only enjoy less than they otherwise would enjoy, but they produce less than they otherwise would produce. The state is not a richer state, but on the contrary, it is a poorer state by such a policy. For a portion of her capital is employed in a channel in which it is less productive than it would have been in the channel into which it would have gone of its own accord. It is a point established in the science of political economy, that it is not good policy to confine consumption to any sort of home

manufacture when it can be purchased more cheaply abroad. The reason is this: that in doing so, that country loses, or wastes the labor of men who could be employed in producing some article more rare or more valuable. This could be exported and exchanged for the article in demand, manufactured by a foreign country, which might possess many natural advantages that enabled it to produce the article at less expense than it could be produced at home, and could, therefore, afford to give much more of it than the domestic manufacturer. The policy, therefore, of holding a colony for the benefit of its trade, is one which tends directly to impoverish a nation.

A colony may be formed and retained for the sake of the gold and silver it may produce. Of this kind, we have a specimen in the former Spanish colonies of Mexico and Peru. If it be asked, whether any advantage can be derived from a colony of this description, the answer is this: in one case alone can it be advantageous to the mother country—that is, the case in which the colony contains the richest mines in the world. These always supply the whole world, when they contain the precious metals; because, from those mines the metals can be afforded cheaper than the expense of working them will allow them to be afforded from other mines, and the principle of competition always excludes the produce of all other mines from the market.

Now the country which contains the richest mines, may so order matters as to gain from foreign countries, on all the precious metals which she sells them, nearly the whole of that difference which exists between what the metal in working costs to her, and what it costs at the mines which, next to hers, are the most fertile in the world. It is now sufficiently understood, that money, in any country, supposing other things to remain the same, is valuable just in proportion to its quantity. Take Mr. Hume's supposition, that England were walled round by a wall of brass, and that the quantity of her money were, in one night, either raised to double, or reduced to half. In the first case, every piece would be reduced to half its former value; in the second place, it would be raised to double its former value, and the value of the whole would remain exactly the same. The country would, therefore, be neither the richer nor the poorer; she would neither produce more, nor enjoy more on that account. It is never, then, by keeping the precious metals, that a country can derive any advantage from them; it is by the very opposite, by parting with them. If a country has been foolish enough to hoard up a quantity of the produce of its capital and labor in the shape of gold and silver, it may, when it pleases, make a better use of it. It may exchange it with other countries for something useful. Gold and silver, so long as they are hoarded up, are of no use whatever. They contribute neither enjoyment nor production. Something use-

ful may be purchased with them, or something that is an article of enjoyment, and then they contribute to happiness; or they may be expended for some materials of manufacture, or for the necessaries of the laborer, and then they contribute to production, and augment the riches, active capital, and the annual produce of the country. But so long as any country hoards up gold and silver, so long as it abstains from parting with them to other countries, so long it deprives itself of the advantages derivable from a judicious investment of capital.

Colonies are a grand source of wars. There is nothing to which history bears so invariable a testimony as this. Nothing is more remarkable in the annals of mankind than the frivolous causes which have often sufficed for going to war, even when there was little or no prospect of gaining, and often when there was the greatest prospect of losing by it. But if the motives for engaging in war are so very strong, in governments which are perfectly despotic, they are much stronger in governments of which the power is still in any great degree limited and restrained. For there is nothing so well calculated for getting rid of all limit and restraint, and strengthening the power of a government, and riveting its chains upon the necks of its subjects, as wars. The power of almost all governments is greater during war than during peace. But it is particularly so in the case of limited governments. In the first place, there is the physical force of the army, and the terror and awe it impresses upon the minds of men. In the next place, there is the splendor and parade which captivate and subdue the imaginations of the unthinking, and make them contented to be slaves. Then there is the additional power entrusted to government; and moreover, when the government is limited by the will of a certain portion of the people, as the British government is by the will of those who supply with members the two houses of Parliament, war affords the greatest portion of the precious matter with which that will may be guided and secured.

Nothing augments so much the quantity of that portion of the national wealth, which is placed at the command of the government, as war. Of course, nothing puts it in the power of the government to create so great a number of dependants, and such a number of persons bound by their hopes and fears, to do and say whatever government desires.

With regard to additional expense, whenever a war breaks out, additional troops and additional vessels are always required for the protection of the colonies. Even during peace, the colonies afford the pretext for a large portion of the peace establishment, as it is called; that is, a mass of warlike apparatus and expense, which would be burdensome, even in a season of war.

That the colonies multiply exceedingly the causes and pretexts of

war, is matter of history. Whatever brings a nation into jealous contact with a greater number of states, increases in the same proportion, those clashings of interest and pride out of which the pretexts for war are frequently created. And a great proportion of the wars that have arisen in modern Europe have, upon actual examination and historical testimony, been proved to have arisen out of colonial disputes.

We can now easily form an estimate of the respective disadvantages accruing to a country and its colonies from the dependence of the latter. The mother country incessantly incurs great expense, and is constantly liable to be plunged into the innumerable evils of war, on account of her colonies. At the same time, the commerce of the colonies and their internal policy, are so much interfered with, and all their energies are so much paralyzed by the selfish and foolish restrictions imposed by the mother country, that they can enjoy nothing like the prosperity which would be secured to them by independence. So far as an extensive commerce is concerned, there can be no comparison between the consumption of a flourishing, independent community, and that of a languishing colony. Thus the 100 millions of British subjects in India, import from her annually only about four millions of pounds' worth of her goods, while the 20 millions of the United States import from Britain to the amount of more than double that sum; and this, although the India trade is exclusively in the hands of the British, while the United States are free to purchase everything wherever they please. Rapidly as the population of the United States has increased since they became independent, the amount of British goods they consume has increased much faster.

It is not difficult to see why countries cling so eagerly to dependent colonies. They are a means of bringing money and power into the hands of the government, and of a few cliques who co-operate with it. These are generally the most influential classes in the community; and although they could easily see that the connection is a national loss, they will be slow to see what they do not wish to believe; and the national loss is their pecuniary profit.

INDEX.

A

I

J

K

L

M

N

T

THE END.